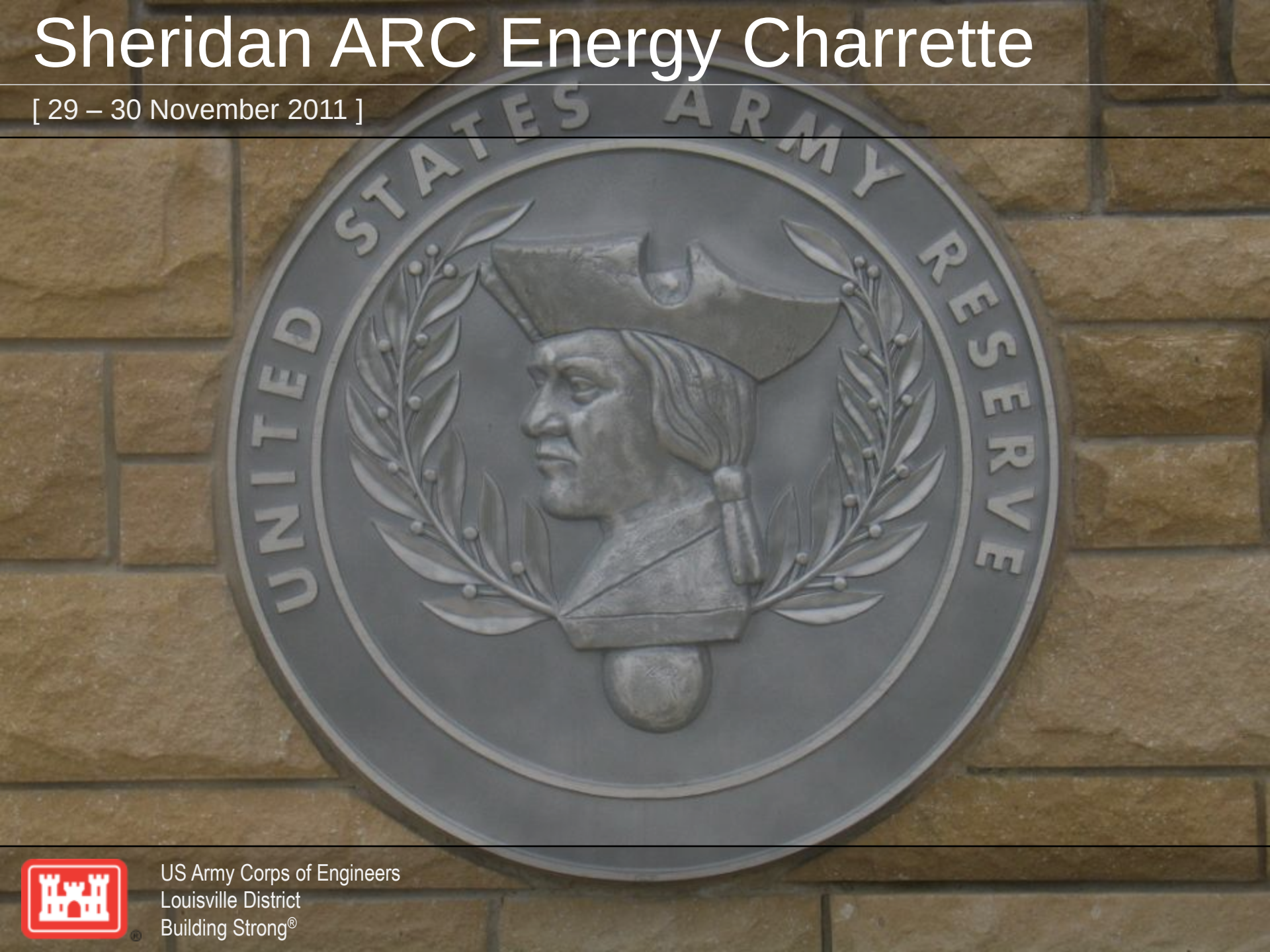
Sheridan ARC Energy Charrette

[29 – 30 November 2011]



US Army Corps of Engineers
Louisville District
Building Strong®

Introductions | Opening Remarks

[key players & decision makers]

- ARIMD Project Officer
- USACE – Louisville District
- 88th RSC
- Sheridan Facility Operations
- Others

Remarks:

- ARIMD Project Officer
- USACE – Louisville District PM

Agenda Overview

[summary]

Day 1 | Project Introduction + Establish Parameters

Goals + Process

Project Scope

Current Parameters | Governing Criteria

Site Constraints | Organization

Energy Modeling | Parameters + Assumptions

Building Envelope Study

Day 2 | Data Presentation + Integration

Updates: Site | Adjacencies

Energy Reduction + Conservation

Summarize Decisions | Discussion

Charrette Wrap-up | Way Ahead

Energy Charrette | Goals

[holistic design approach]

Charrette Goals:

Present findings for regional and local energy reduction solutions.

Energy Charrette Products Include:

1. Proposed site plan, massing models, and proposed floor plan adjacencies.
2. Capture decisions for implementation of Energy Conserving Measures (ECMs).

Holistic Design:

Project goals must be identified during conception and held in proper balance throughout the design and construction. Design should explore the interrelationships and interdependencies of each objective.

1. Environmental impacts.
2. Sustainability.
3. Functional/Operational.
4. Precedence.
5. Energy Conserving Measures (ECMs):
   - Energy Consumption
   - Energy Cost.
   - Minimize O&M.

[synergetic approach]

Energy Charrette | Process

[holistic design approach]

Process:

[Homework] - Pre-Energy Charrette Study:

1. Identify Federal Mandates.
2. Identify Army Reserve Energy Reduction Guidance (Long Term Goals).
3. Understand program requirements (Straw-Man).
4. Define Site Constraints & develop Adjacencies Plan.
4. Brainstormed potential strategies/ideas for energy reduction initiatives.
5. Define building Baseline Model (ASHRAE 90.1-2007).
6. Researched and analyzed strategies and ideas.

[Decisions] - Energy Charrette:

7. Present findings and justification for potential initiatives.
8. Capture decisions.

[Implement] - Design & Development:

9. Incorporate initiatives into design (Optimize Design).
10. LEED Documentation.

[Benchmark: 3rd Party Validation] - Construction Phase:

11. GBCI Certification.

Project Scope | DD1391

[PN 67659 | PA $28M]

TRNG → Training Building
OMS → Maintenance Building
UHS → Unheated Storage Building

PRIMARY FACILITY				19,683
Training Building	SF	75,258	214.60	(16,150)
Maintenance Building	SF	6,651	302.47	(2,012)
Unheated Storage Building	SF	4,001	123.38	(494)
Sustainability/Energy Measures	LS	--	--	(382)
Antiterrorism Measures	LS	--	--	(191)
Building Information Systems	LS	--	--	(454)
SUPPORTING FACILITIES				5,826
Electric Service	LS	--	--	(443)
Water, Sewer, Gas	LS	--	--	(591)
Paving, Walks, Curbs And Gutters	LS	--	--	(473)
Storm Drainage	LS	--	--	(148)
Site Imp(1,774) Demo(856)	LS	--	--	(2,630)
Information Systems	LS	--	--	(297)
Antiterrorism Measures	LS	--	--	(47)
DEMARC Relocation	LS	--	--	(1,198)

ECC → ESTIMATED CONTRACT COST

ESTIMATED CONTRACT COST	25,509
CONTINGENCY (5.00%)	1,275
SUBTOTAL	26,784
SUPERVISION, INSPECTION & OVERHEAD (5.70%)	1,527
TOTAL REQUEST	28,311
TOTAL REQUEST (ROUNDED)	28,000
TOTAL RELATED FURNITURE & EQUIP	(2,870)

*DD1391, dated 25 Jul 2011

Current Parameters | Mandates

[governing criteria]

Energy Independent and Security Act (EISA 2007):

"Net Zero Ready"

Zero net energy consumption and zero carbon emissions annually.
Requires that the fossil fuel-generated energy use of the new building is reduced (compared to 2003 Commercial Building Energy Consumption Survey) by:

- 65% for 2015
- 80% for 2020
- 90% for 2025
- 100% for 2030

Energy Policy Act (EPAct 2005):

"Reduce"

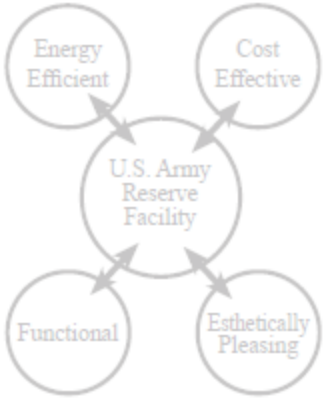
New Federal buildings shall meet or exceed the ASHRAE 90.1-2004 Energy Standard.

Life-cycle cost-effective for new Federal buildings, the buildings shall be designed to achieve energy consumption levels that are at least 30 percent below the levels established in ASHRAE 90.1-2004 Standard.

Current Parameters | Guidance

[guiding criteria]

- UFC 4-171-05, Army Reserve Facilities
- Army Reserve Sustainable Policy
- ARCOS BULLETIN 2011-1 Sustainability and Energy Efficiency
- ASHRAE 189.1-2009 (design to comply)
- ASHRAE 90.1-2007 (model as a baseline)
- ECB 2011-1, High Performance Energy and Sustainability Policy
- Army Reserve Energy Efficiency and Sustainability Policy (ENCLOSURE 1)
- Sustainable Design Development Policy (SDD) (Ref 1.a). ECB 2011-1 (Ref 1.b) and ECB 2010-14 (Ref 1.c)



Current Parameters | 88th RSC Design Guide

[energy & conservation goals]

- Building Envelope 50 year Life Cycle Cost Effective (LCCE) and Systems 40 year LCCE.
- Long Axis E-W orientation to maximize solar exposure.
- Low E insulated glazing: operable windows (clerestory and monitors). Skylights are discouraged.
- “Solar Wall” panels used to preheat air.
- Design HVAC system with the lowest LCCE.
  - HVAC system should use On-demand ventilation systems.
  - Geothermal heat pump systems.
  - Ice or Chilled water storage systems.
  - Explore adiabatic cooling of inlet and use return air from office areas to condition atrium areas.
  - Exhaust systems should equipped with heat recovery units to precondition fresh air requirements.
  - In-floor hydronic/radiant heating system for OMS.
- Design high efficiency lighting for entire building (exterior and interior).
- Wind and photovoltaic power generation systems are discouraged until all other more cost effective solutions and passive conservation systems are incorporated.
- Explore the use of low slope vegetated roof.

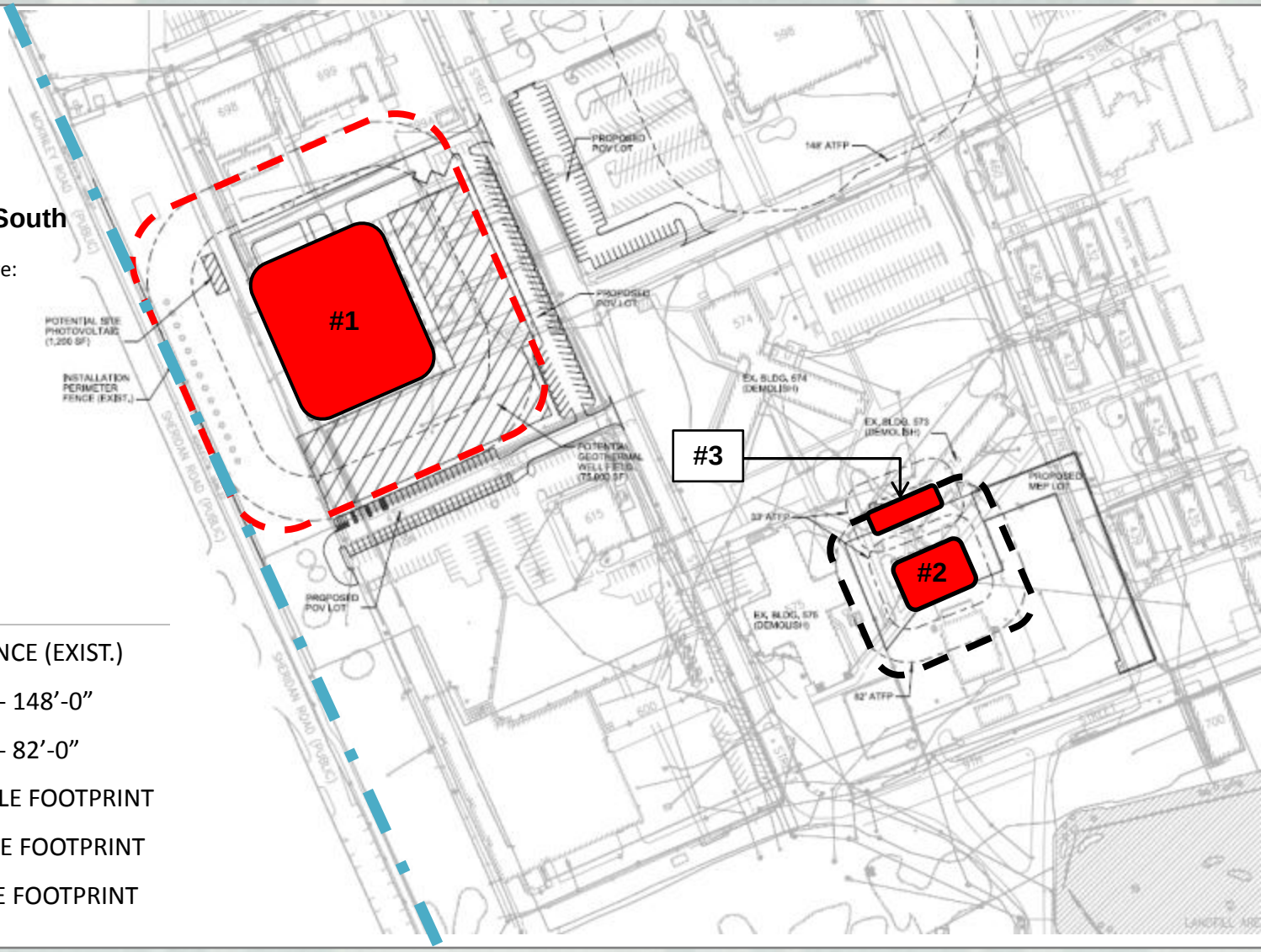
Current Parameters

[site constraints | overall site]

N

Site rotated 21.5° of due South

Optimum rotation for solar exposure:
5° of due South



LEGEND:

- PERIMETER FENCE (EXIST.)
- ATFP SETBACK - 148’-0”
- ATFP SETBACK - 82’-0”

#1: TRNG BUILDABLE FOOTPRINT

#2: OMS BUILDABLE FOOTPRINT

#3: UHS BUILDABLE FOOTPRINT

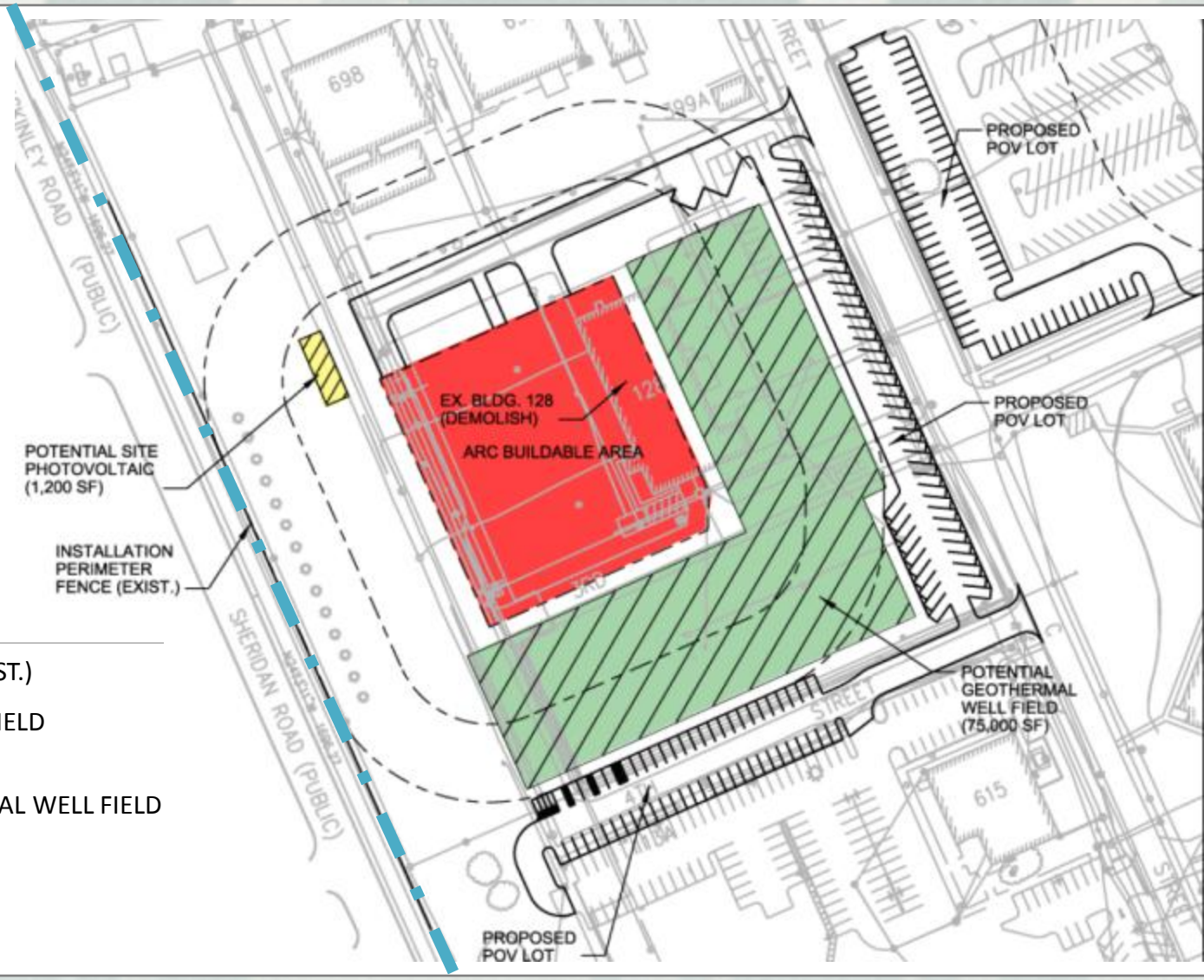
Current Parameters

[buildable footprint: ARC]

N

Site rotated 21.5° of due South

Optimum rotation for solar exposure:
5° of due South



LEGEND:

- PERIMETER FENCE (EXIST.)
- PROPOSED PV ARRAY FIELD (1,200 SF)
- PROPOSED GEOTHERMAL WELL FIELD (75,000 SF)

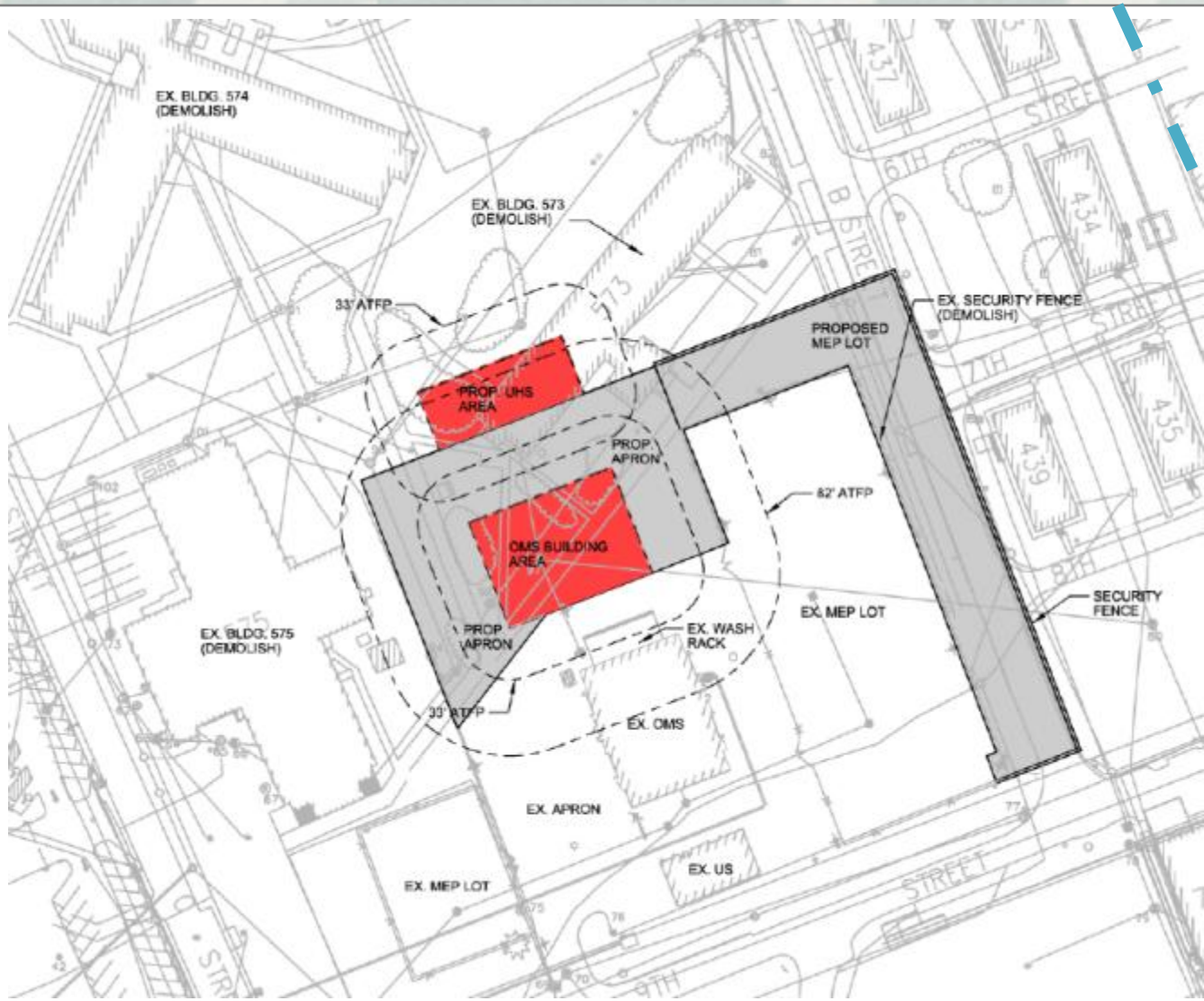
Current Parameters

[buildable footprint: OMS]

N

Site rotated 21.5° of due South

Optimum rotation for solar exposure:
5° of due South

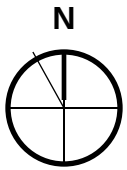


LEGEND:

- PERIMETER FENCE (EXIST.)
- PROPOSED HARDSTAND

Site Organization

[orientation study]



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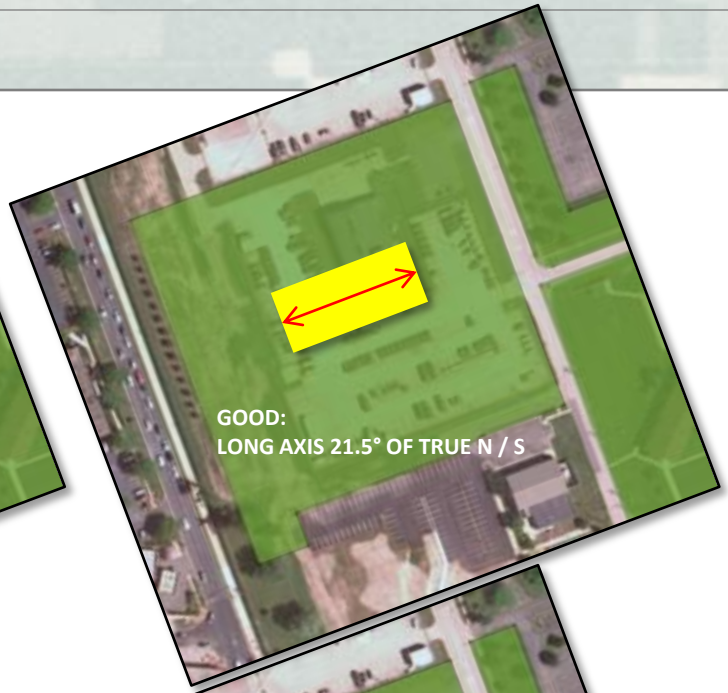
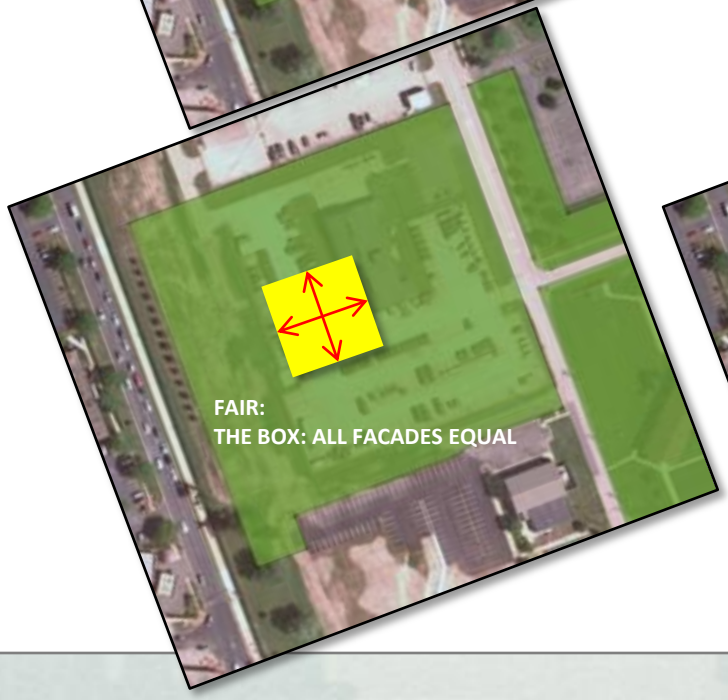




[15 Minute Break]

Preliminary Energy Modeling

[modeling parameters]

Modeling Parameters

1. Building Orientation:

- Dictated by site constraints.

2. ASHRAE 90.1 baseline:

- Space-by-space lighting power density.
- Envelope thermal properties.
- Baseline HVAC systems:
  - ARC: 2 Systems.
  - OMS: 1 System.

Modeling Software

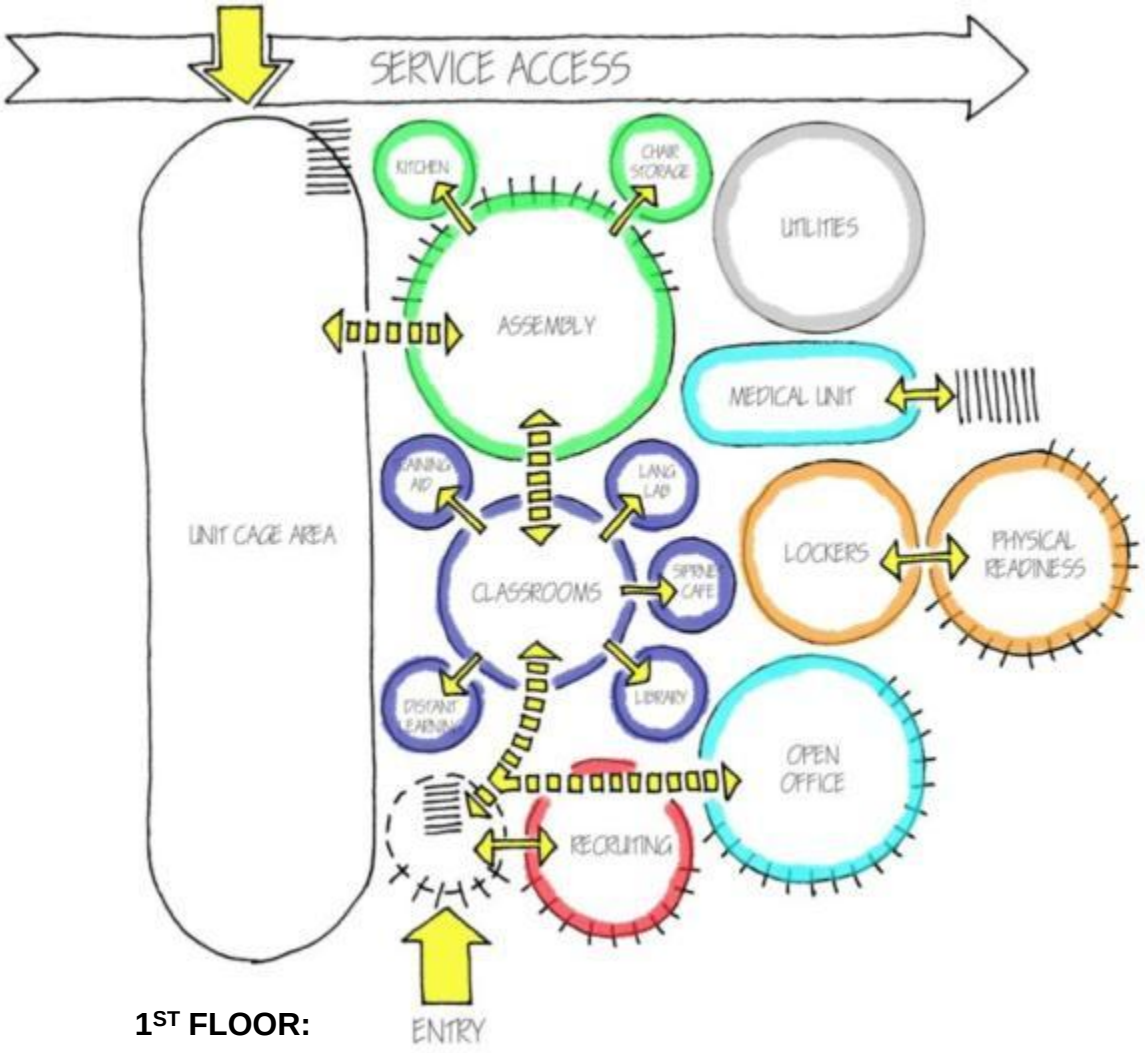
- ECOTECT
- eQuest 3-64, Quick Energy Simulation Tool
- Carrier HAP, Hourly Analysis Program
- Green Building Studio
- Project Vasari
- RETScreen
- NREL Energy Modeling Tools

Modeling Output

- Simulates Daylighting & Building Envelope effectiveness
- Accounts for preliminary HVAC system design
- Provides information for potential proportional savings from energy efficiency measures

Preliminary Energy Modeling | ARC

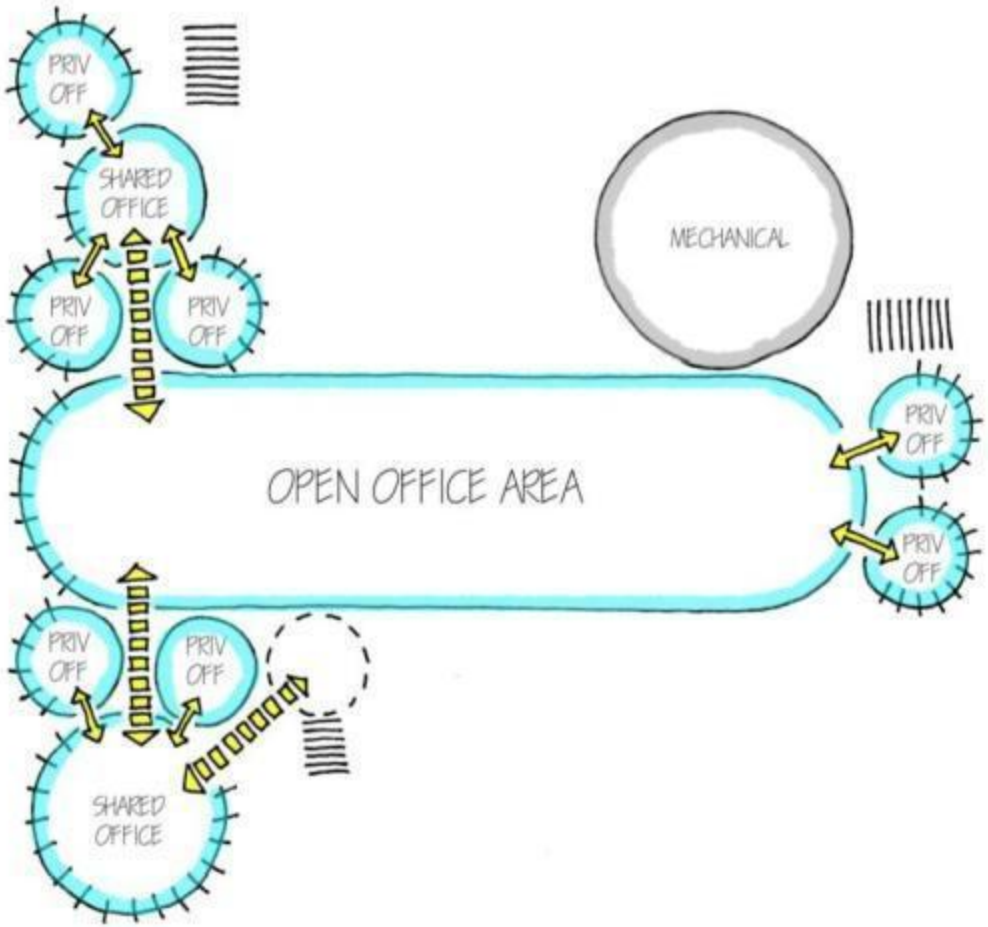
[spatial programming | adjacencies]



1ST FLOOR:

Preliminary Energy Modeling | ARC

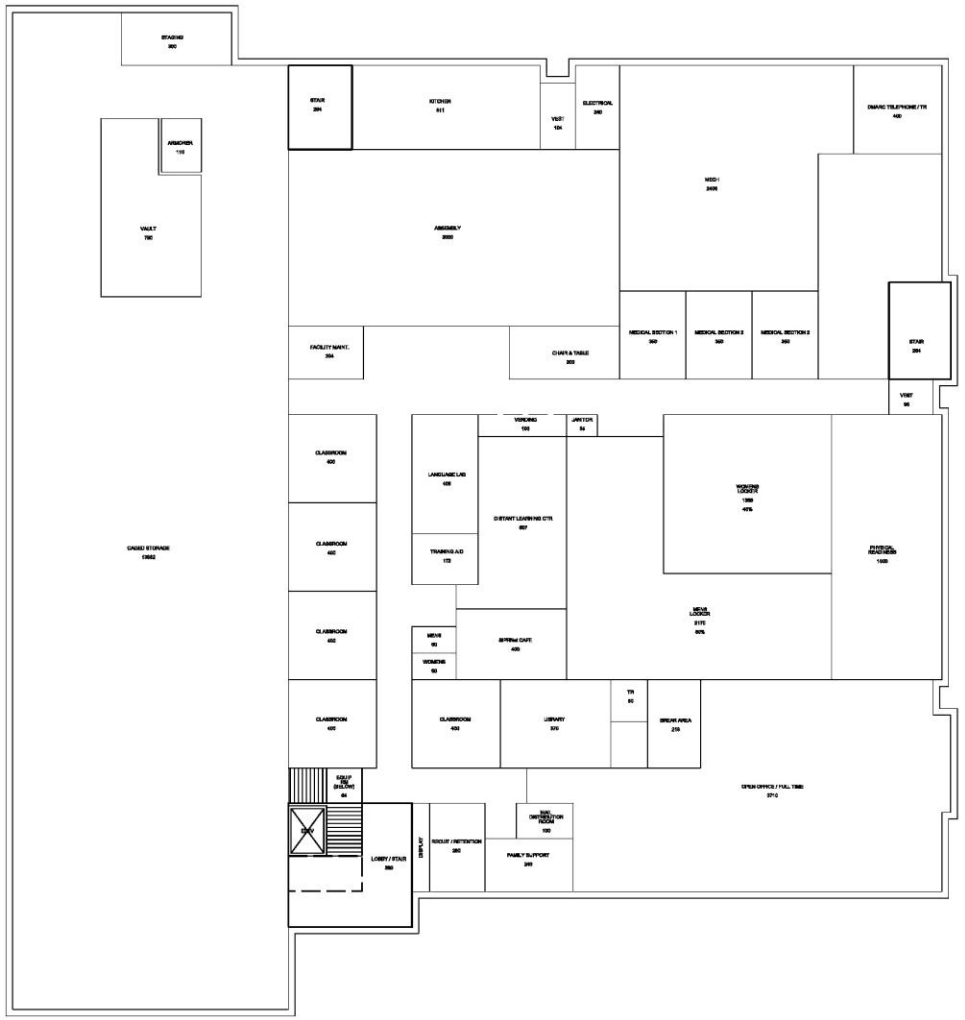
[spatial programming | adjacencies]



2ND FLOOR:

Preliminary Energy Modeling | ARC

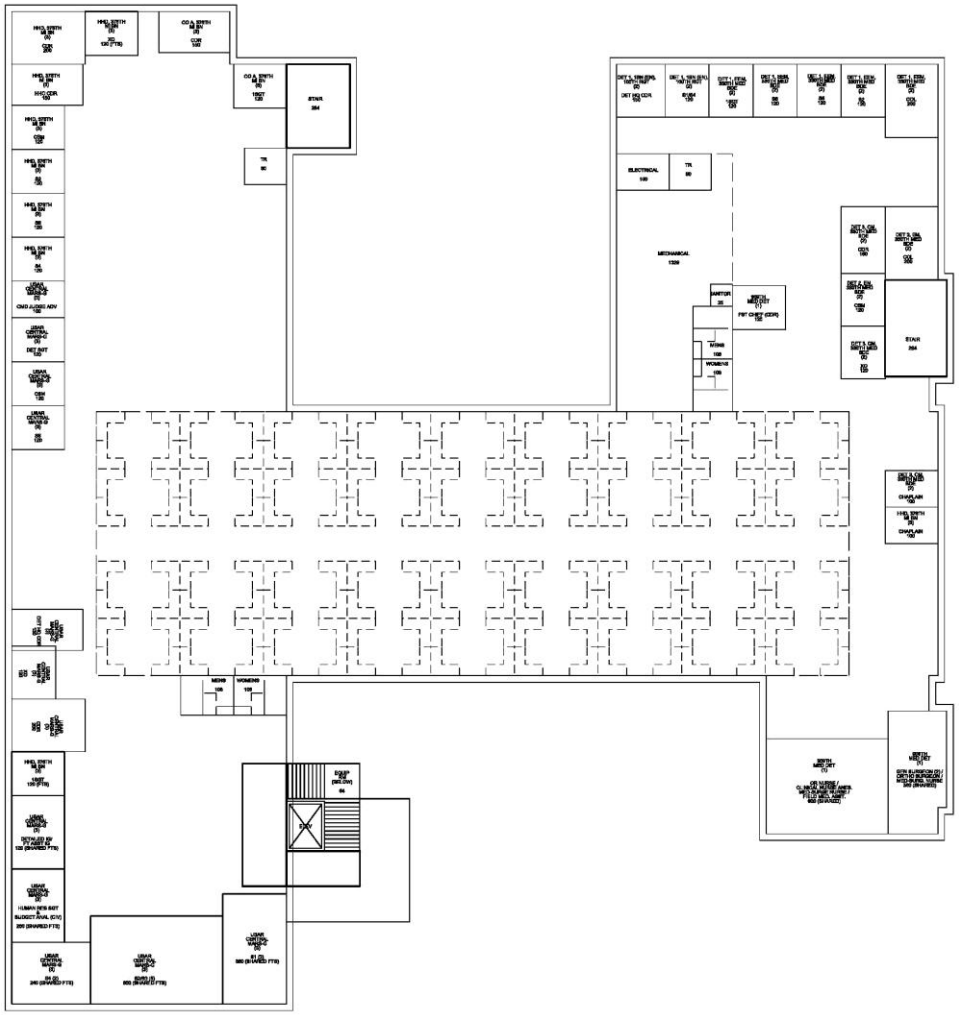
[proposed plan]



1ST FLOOR PLAN:

Preliminary Energy Modeling | ARC

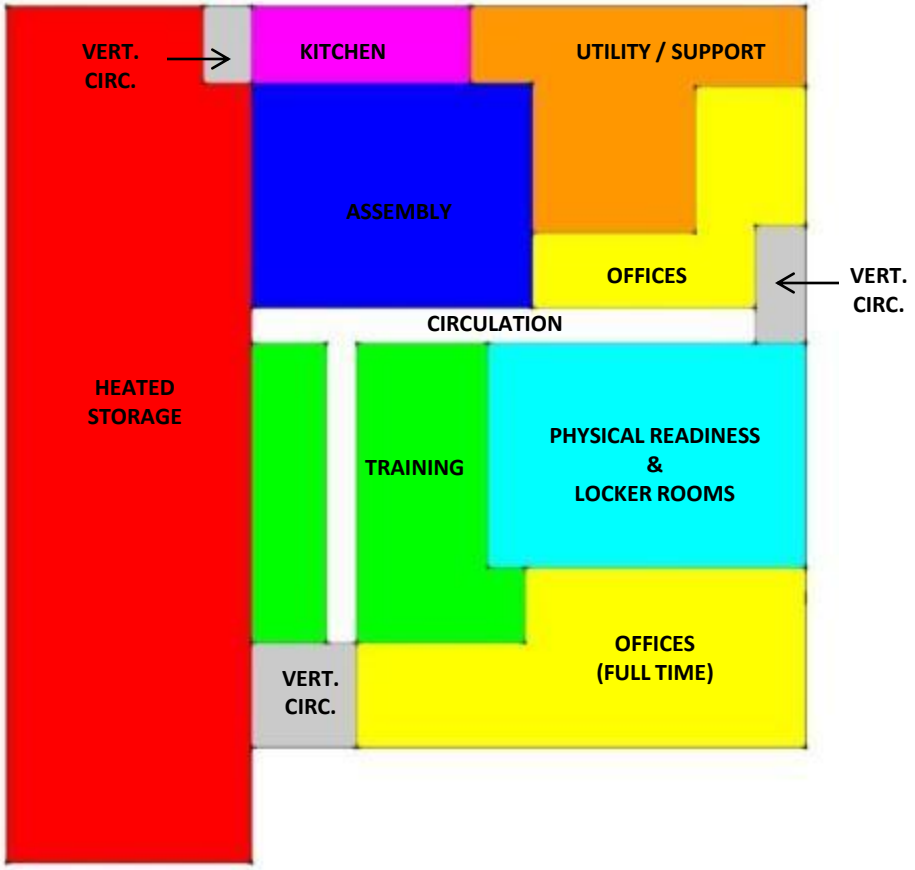
[proposed plan]



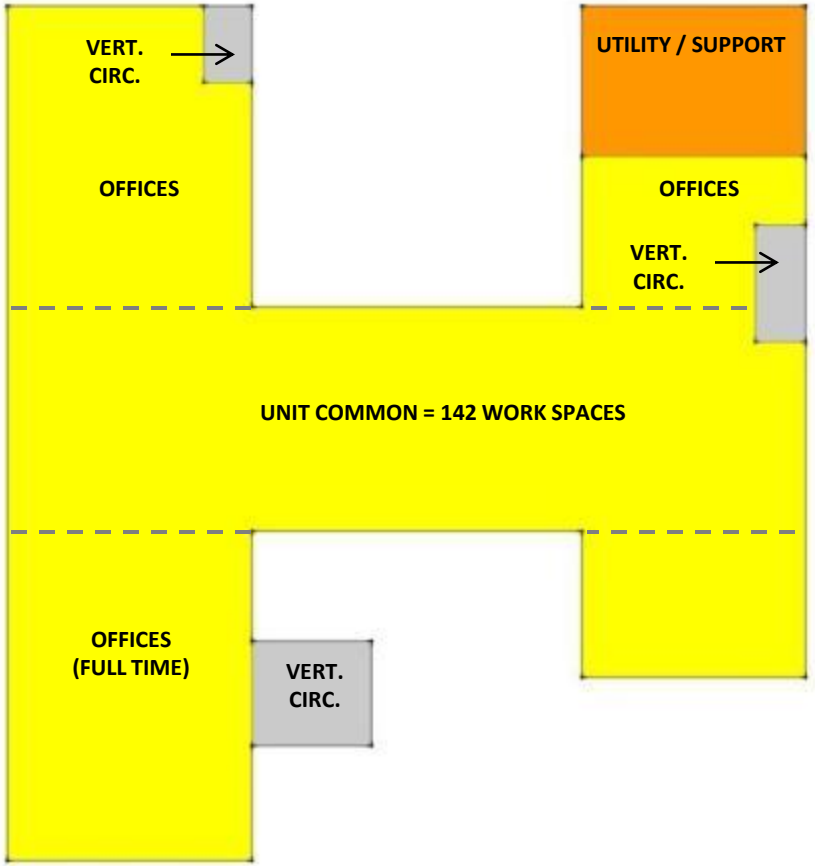
2ND FLOOR PLAN:

Preliminary Energy Modeling | ARC

[preliminary baseline thermal zones]



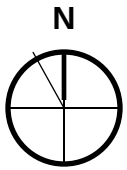
1ST FLOOR: (44,258 SF)



2nd FLOOR: (31,000 SF)

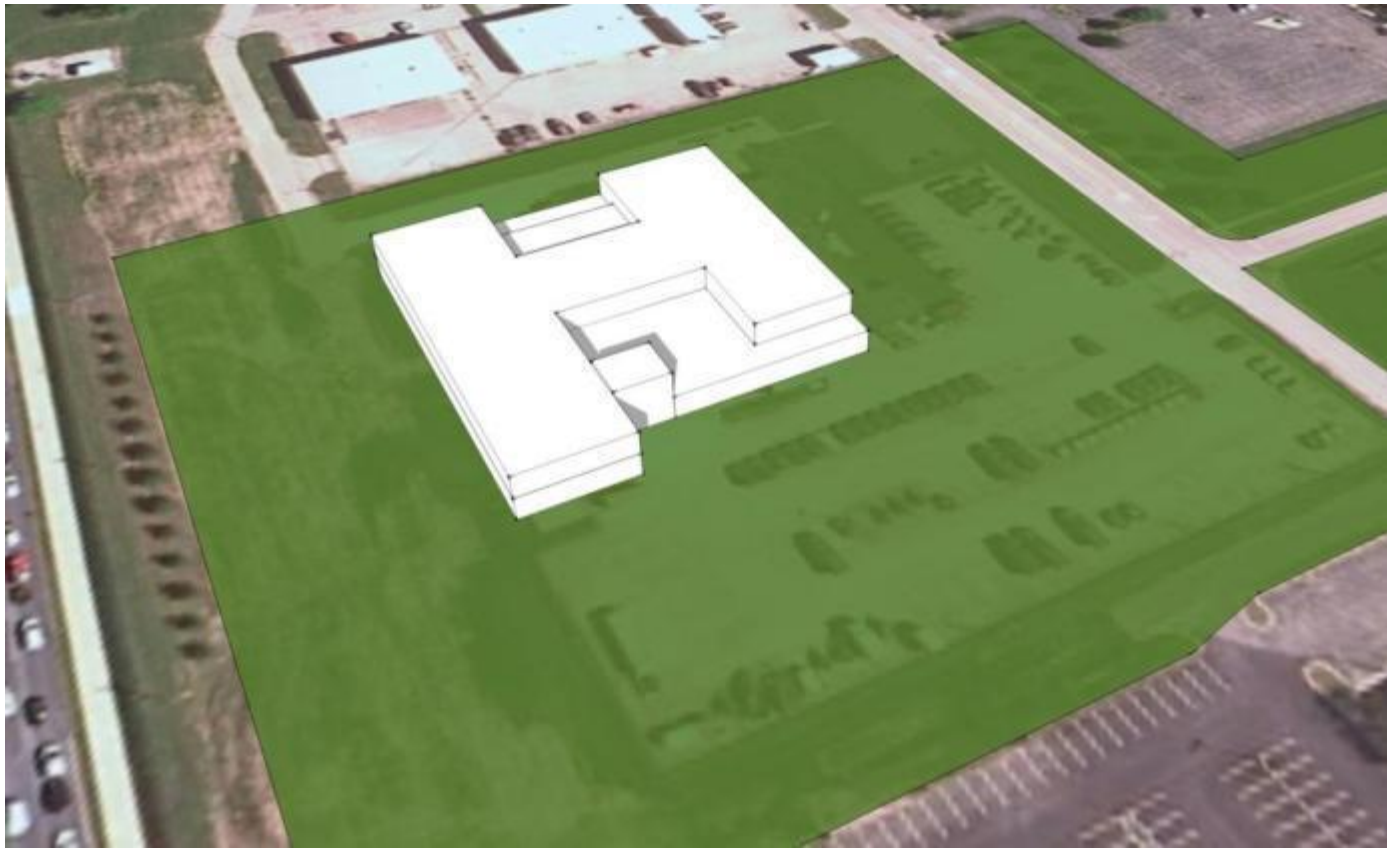
Preliminary Energy Modeling | ARC

[baseline model: ARC]



Site rotated 21.5° of due South

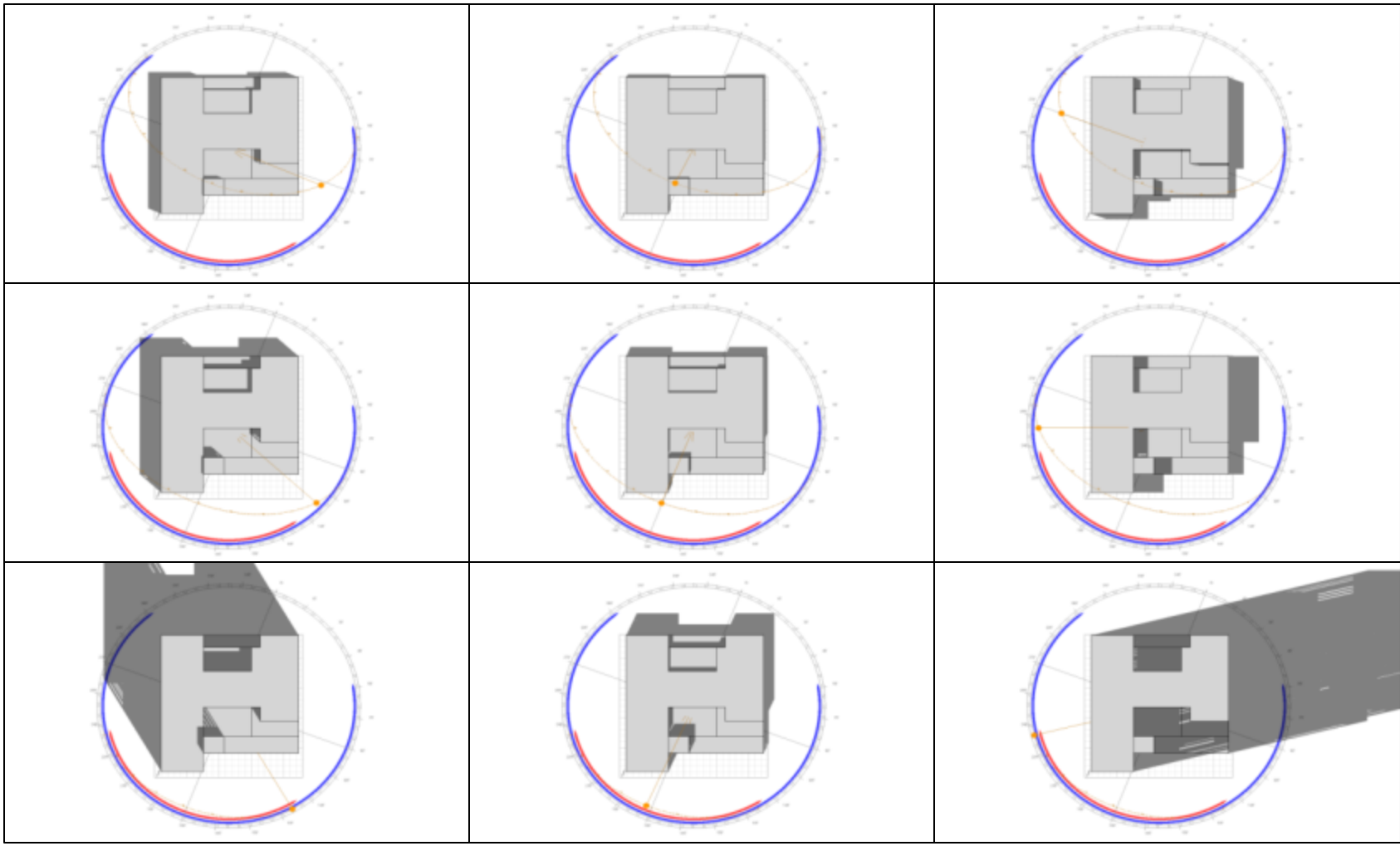
Optimum rotation for solar exposure:
5° of due South



FOOTPRINT: (44,258 SF)

Preliminary Energy Modeling | ARC

[ARC building orientation | site solar shading – plan]



Preliminary Energy Modeling | ARC

[ARC building orientation | site solar shading – perspective]

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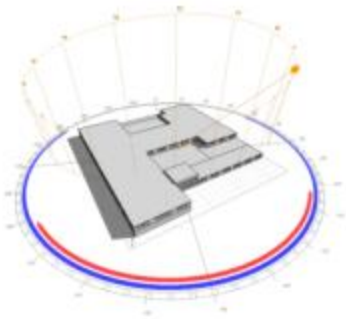
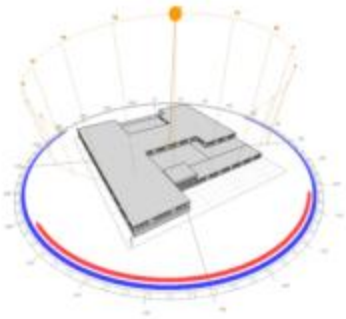
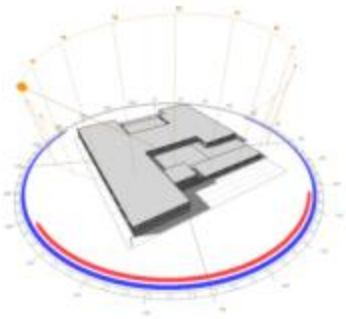
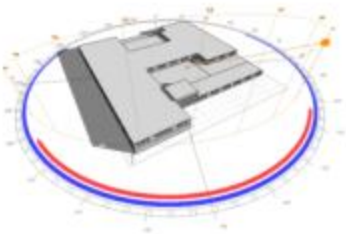
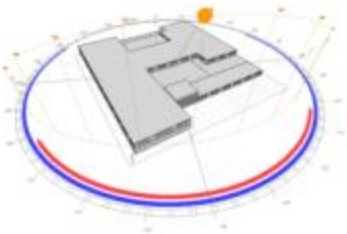
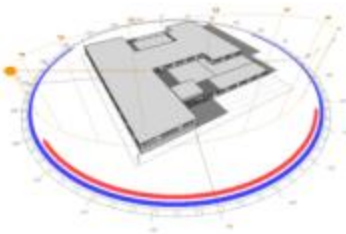
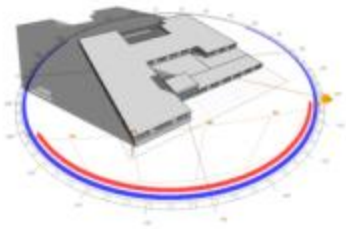
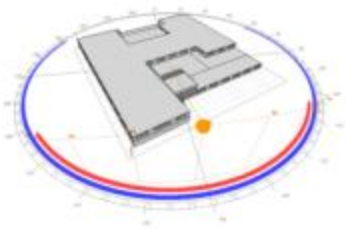
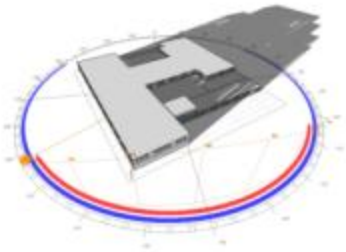
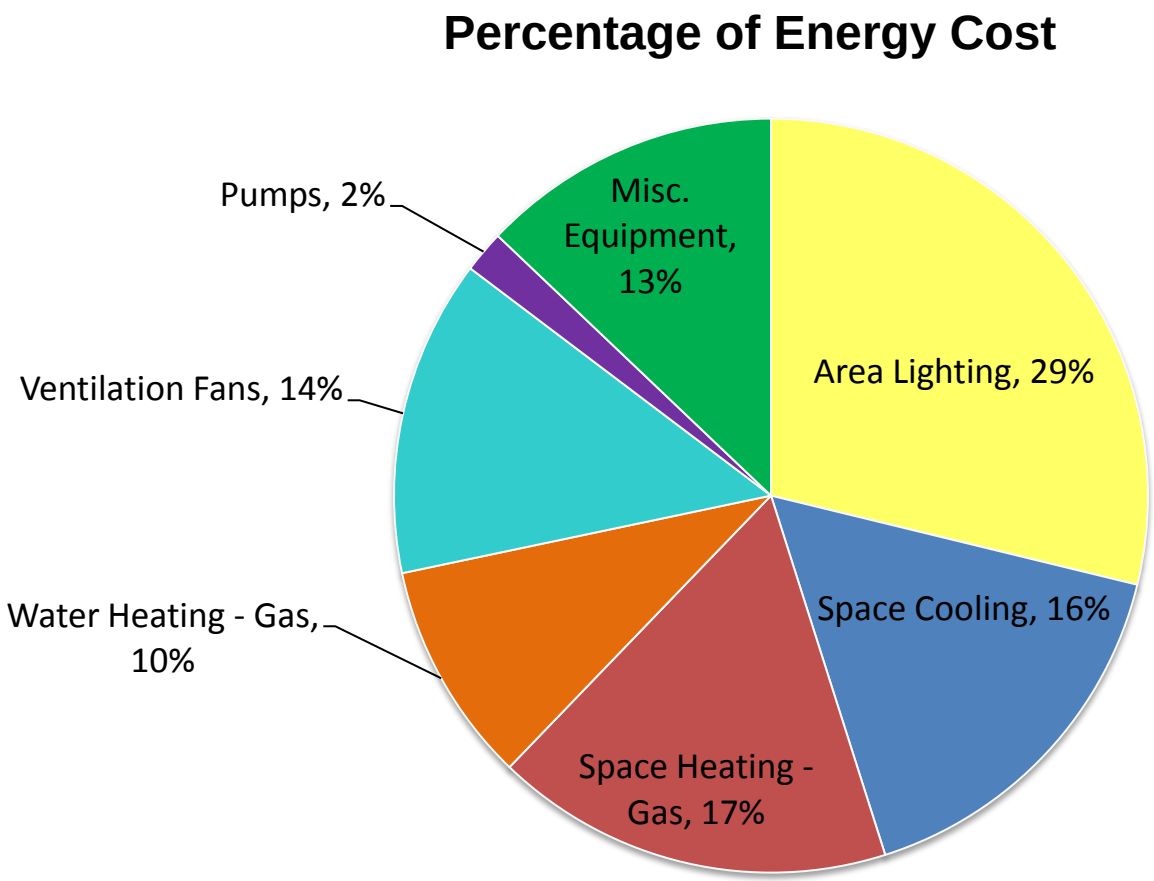
Summer Solstice			
Equinox			
Winter Solstice			

Energy Modeling | ARC

[ASHRAE 90.1 baseline modeling]

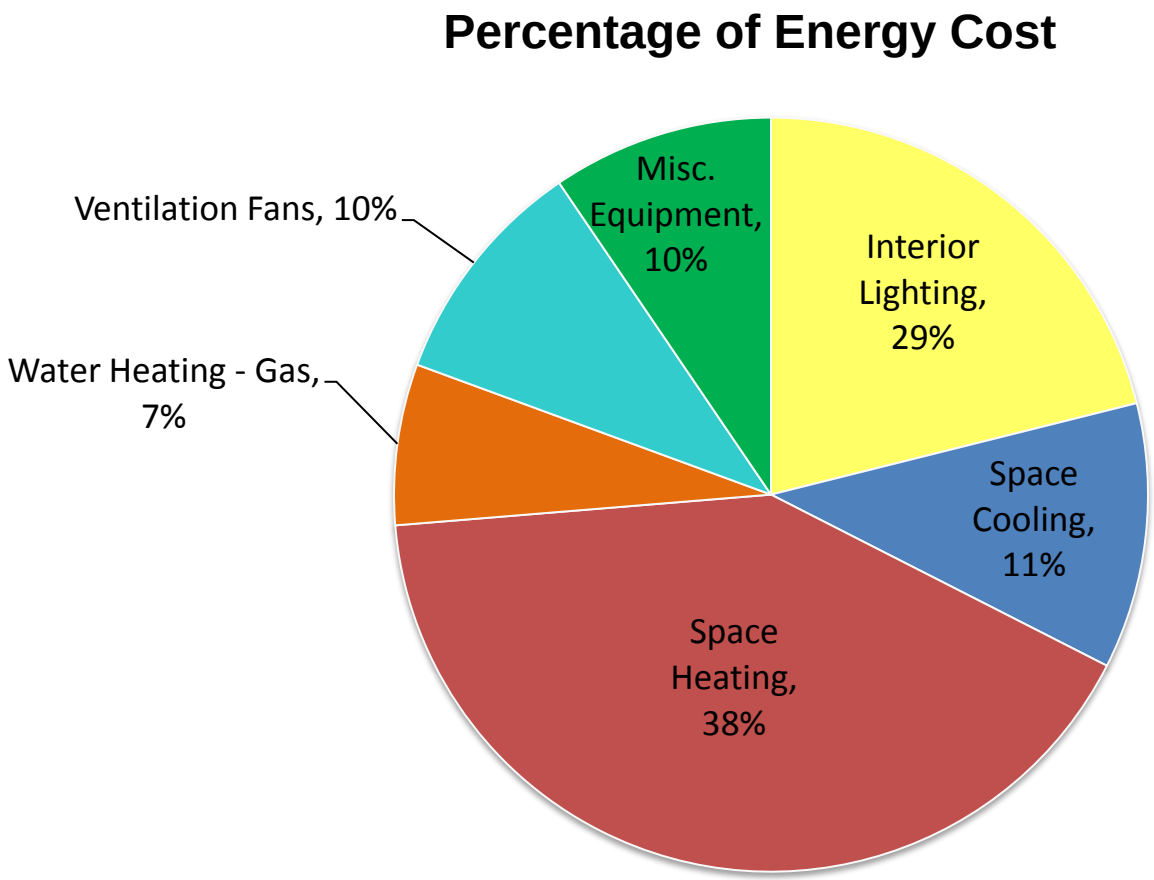
Baseline Gas: VAV DX Cooling / Hydronic Heating



Energy Modeling | ARC

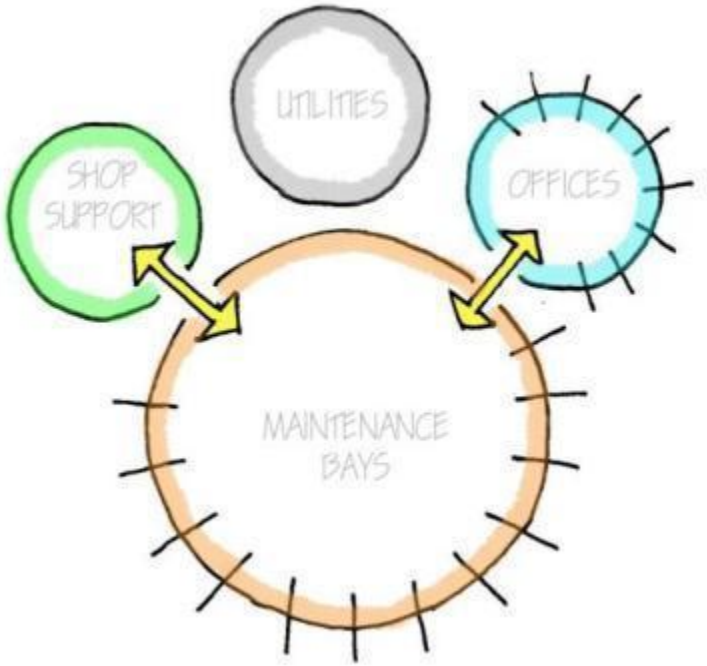
[ASHRAE 90.1 baseline modeling]

Baseline Electric: VAV DX Cooling/Electric Resistance Heating



Preliminary Energy Modeling | OMS

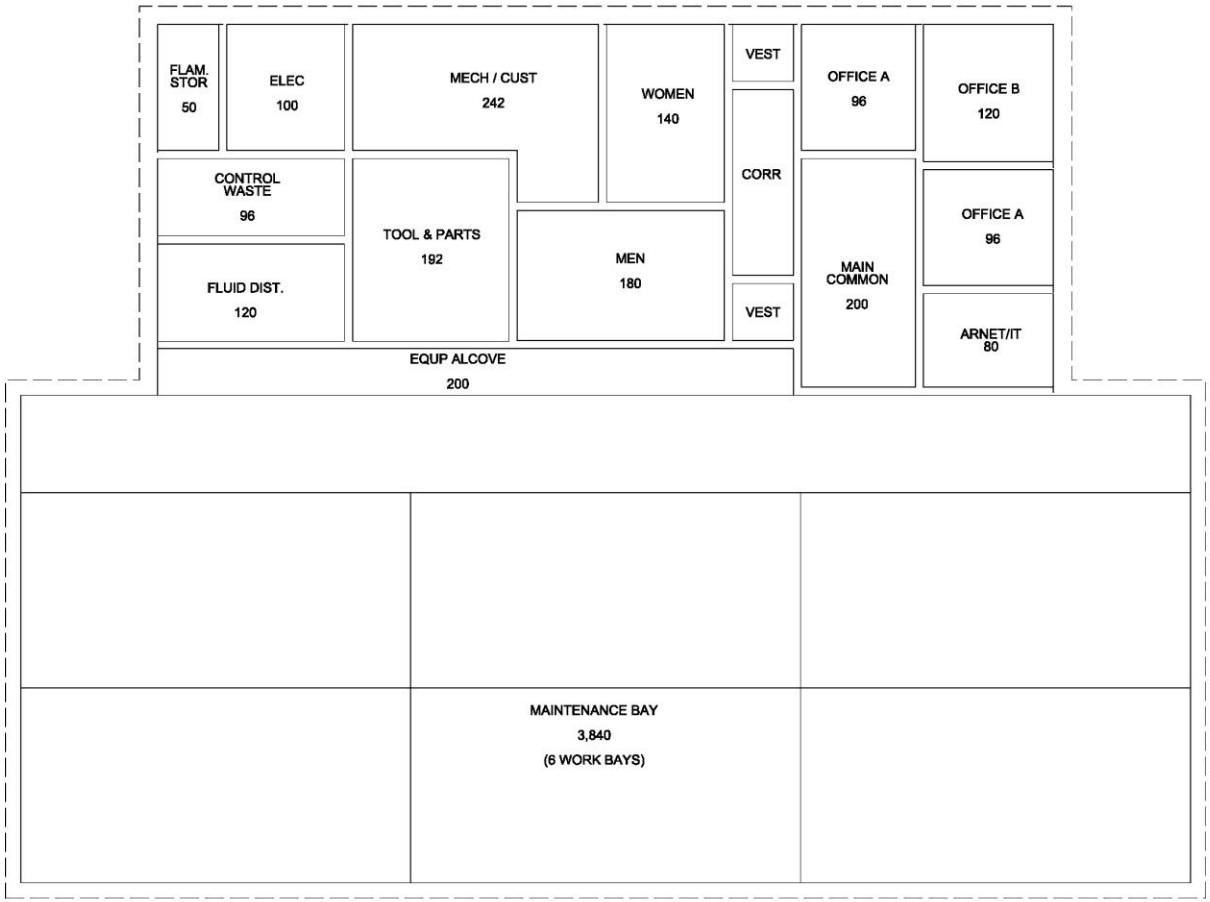
[spatial programming | adjacencies]



1ST FLOOR

Preliminary Energy Modeling | OMS

[proposed plan]

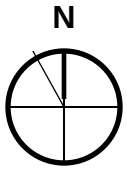


1ST FLOOR PLAN

Preliminary Energy Modeling | OMS

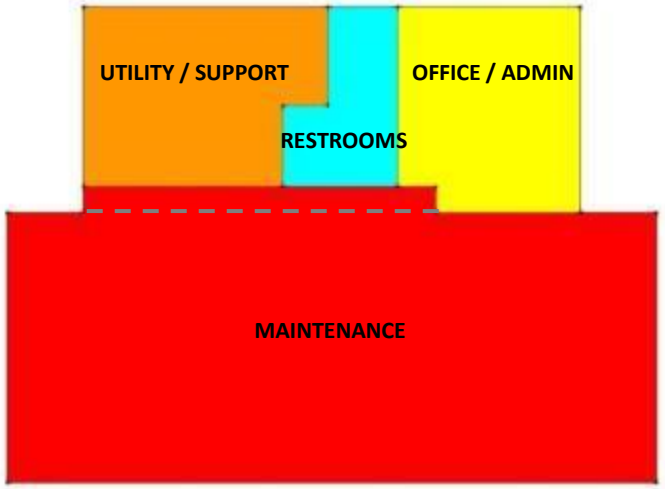
[base model]

[preliminary baseline thermal zones]



Site rotated 21.5° of due South

Optimum rotation for solar exposure:
5° of due South

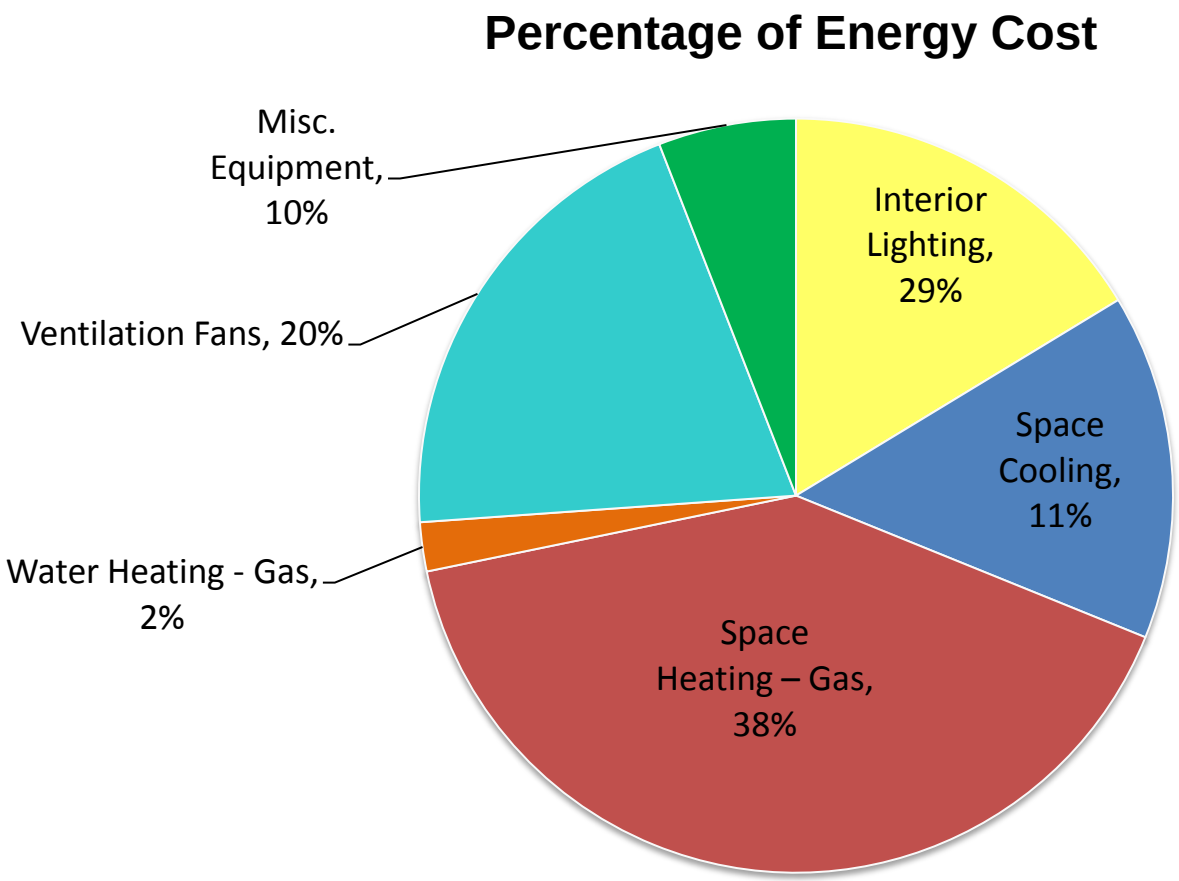


FOOTPRINT: (6,651 SF)

Energy Modeling | OMS

[ASHRAE 90.1 baseline modeling: OMS]

Baseline Gas: Constant Volume DX Cooling/Gas Furnace Heating

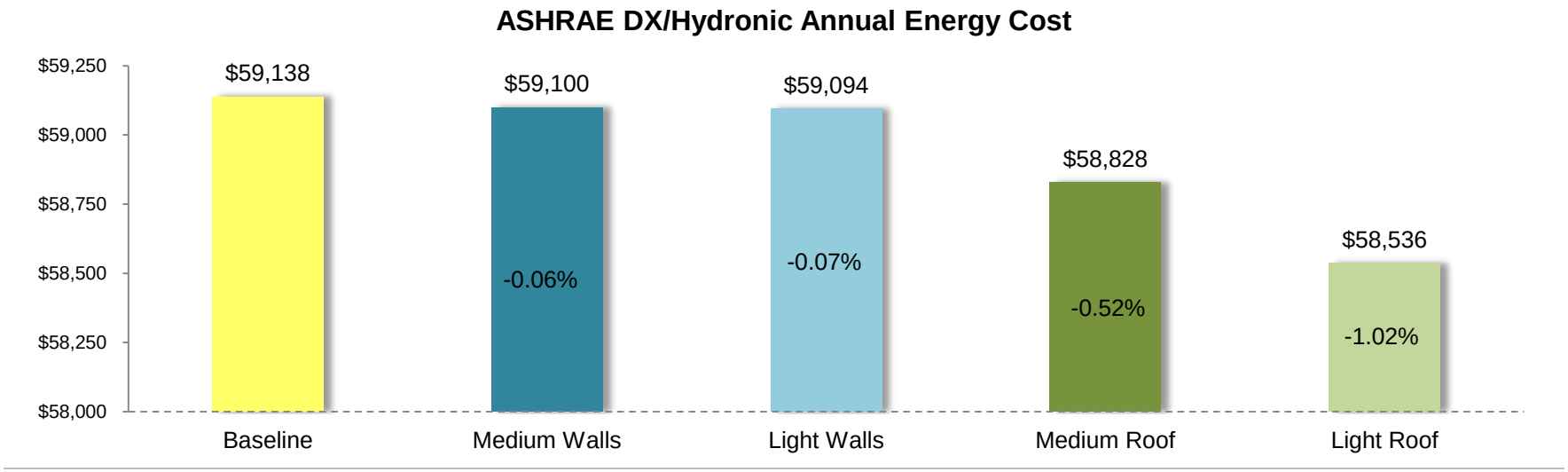


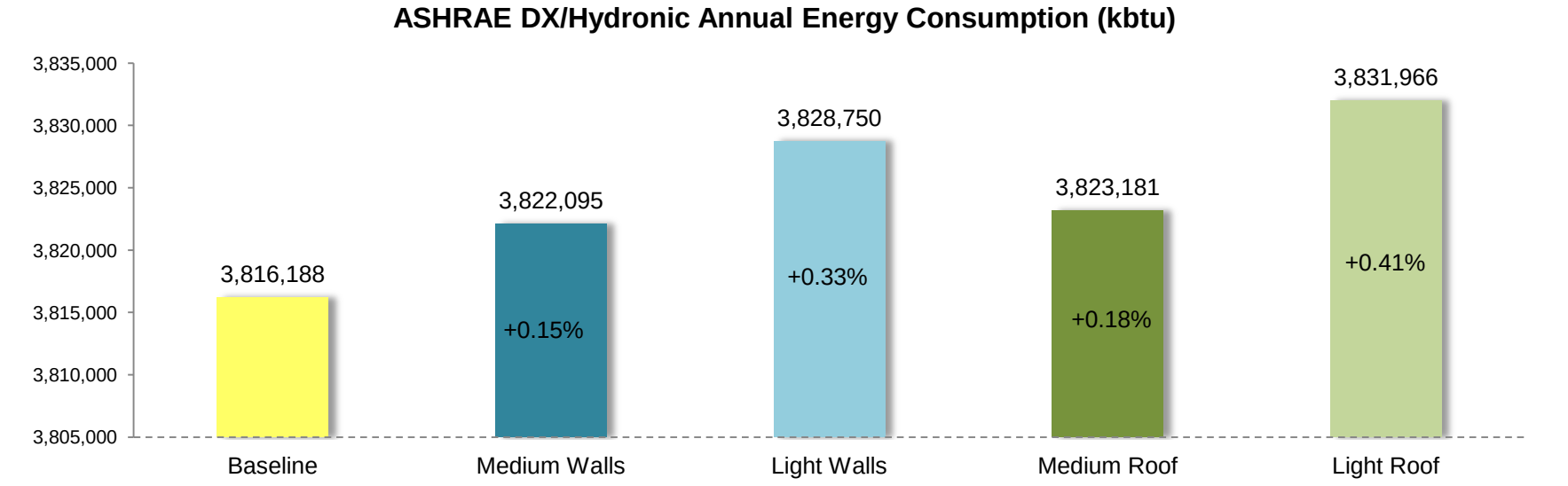
[Lunch]

Alternatives | Discussion

Building Envelope

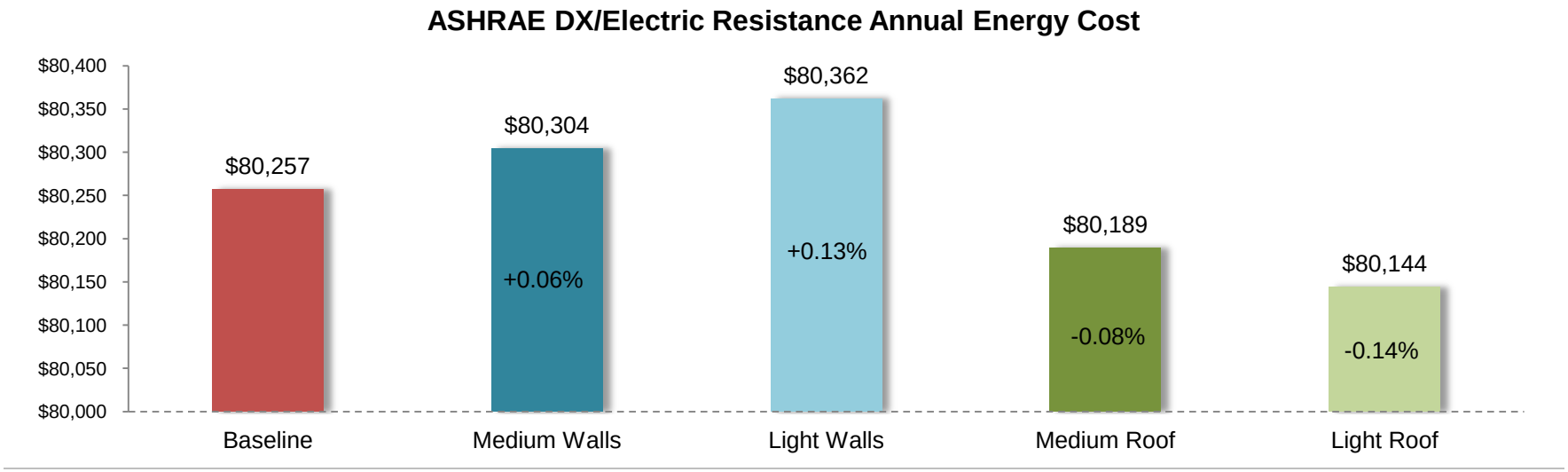
[ARC envelope color | gas heat baseline]

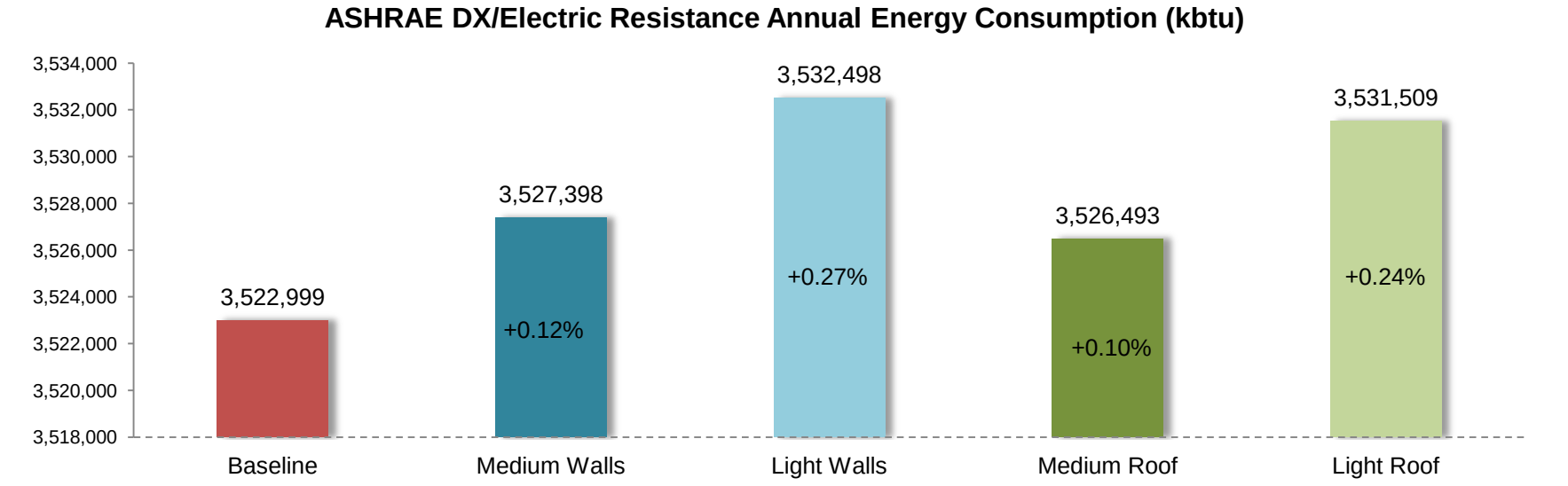




Building Envelope

[ARC envelope color | electric heat baseline]

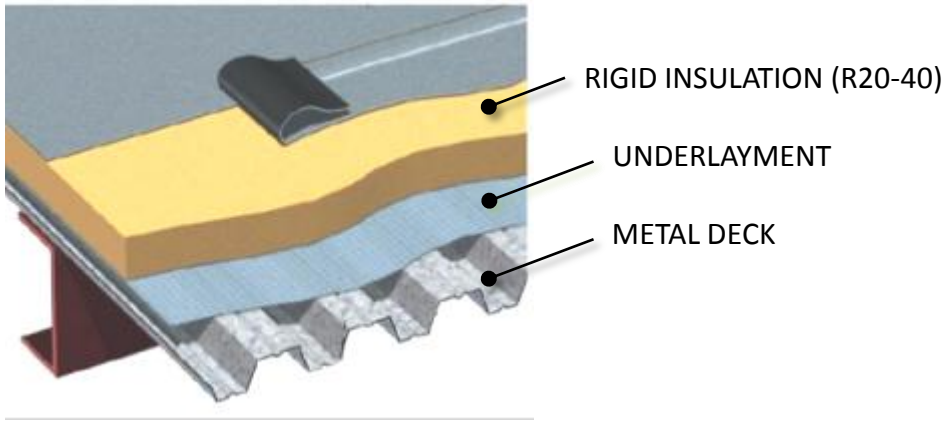




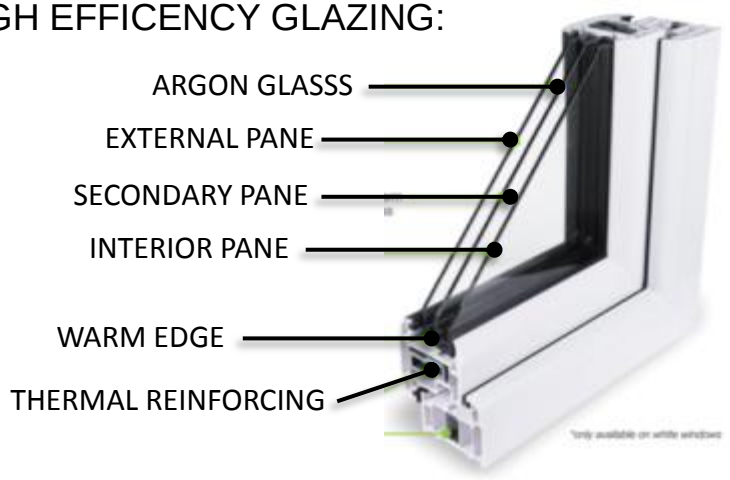
Building Envelope | ARC

[envelope components]

BUILT-UP ROOFING SYSTEM:

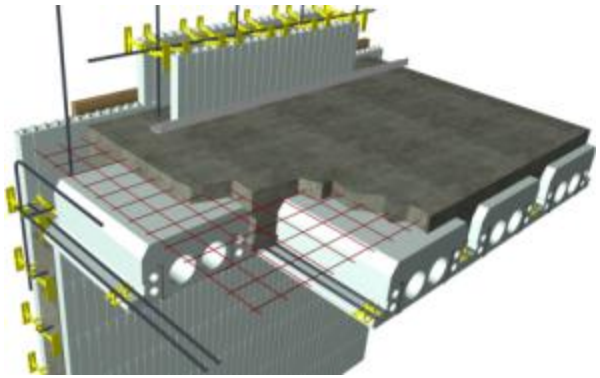


HIGH EFFICENCY GLAZING:



BRICK AND BLOCK CAVITY WALL:

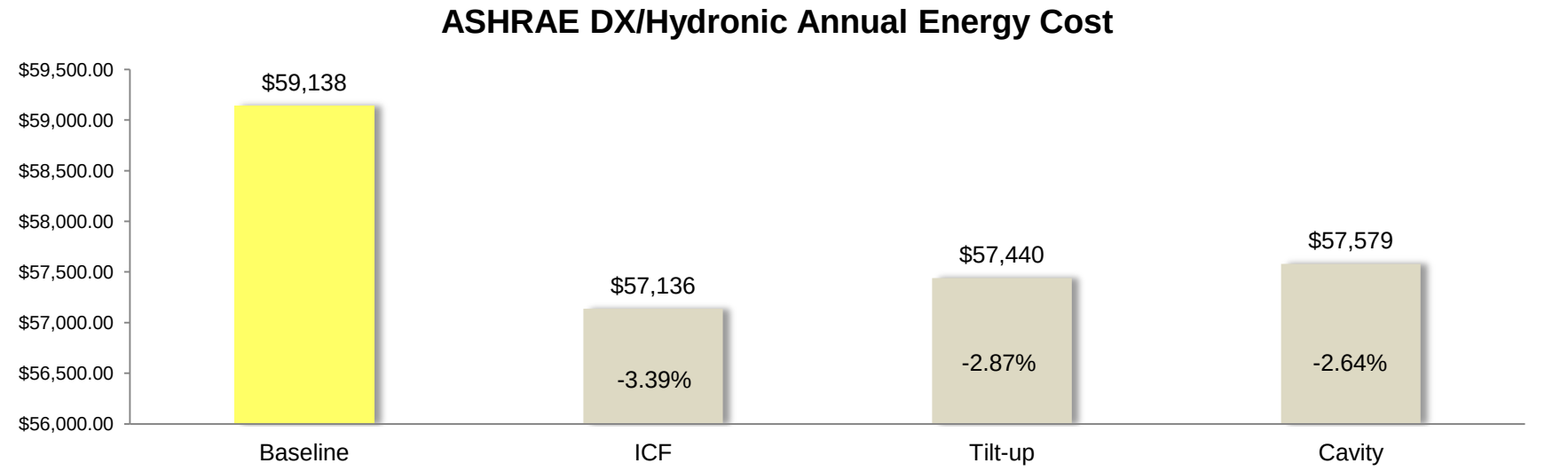
ICF WALL AND FLOOR SYSTEM:

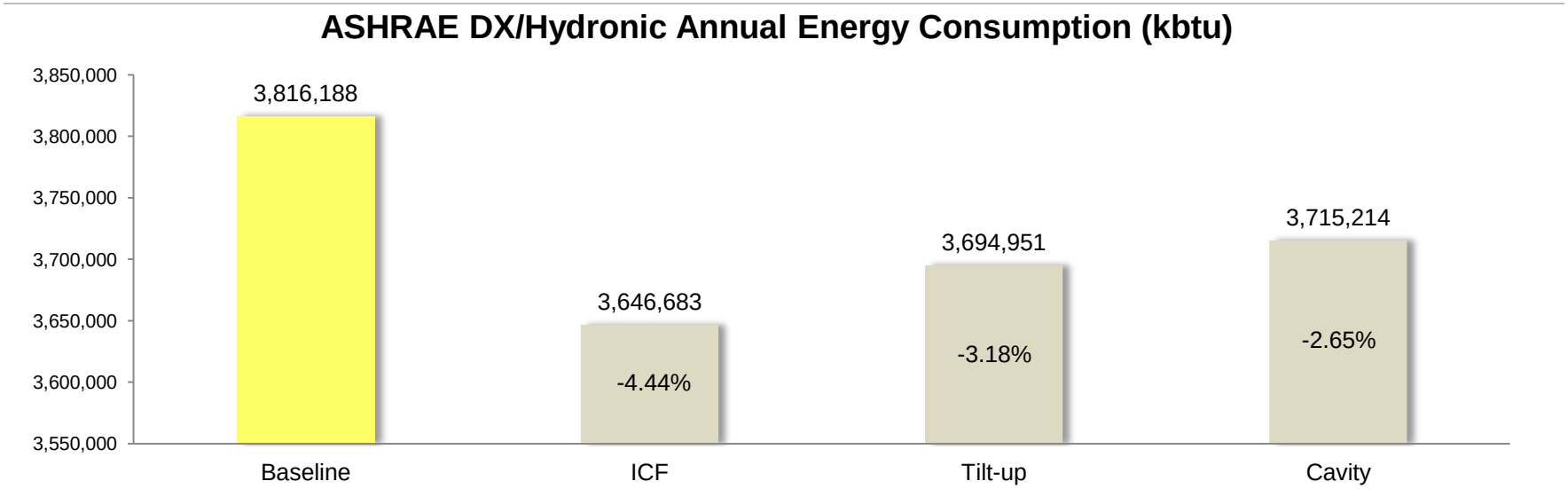


TILT-UP INSULATED PANEL SYSTEM:

Building Envelope

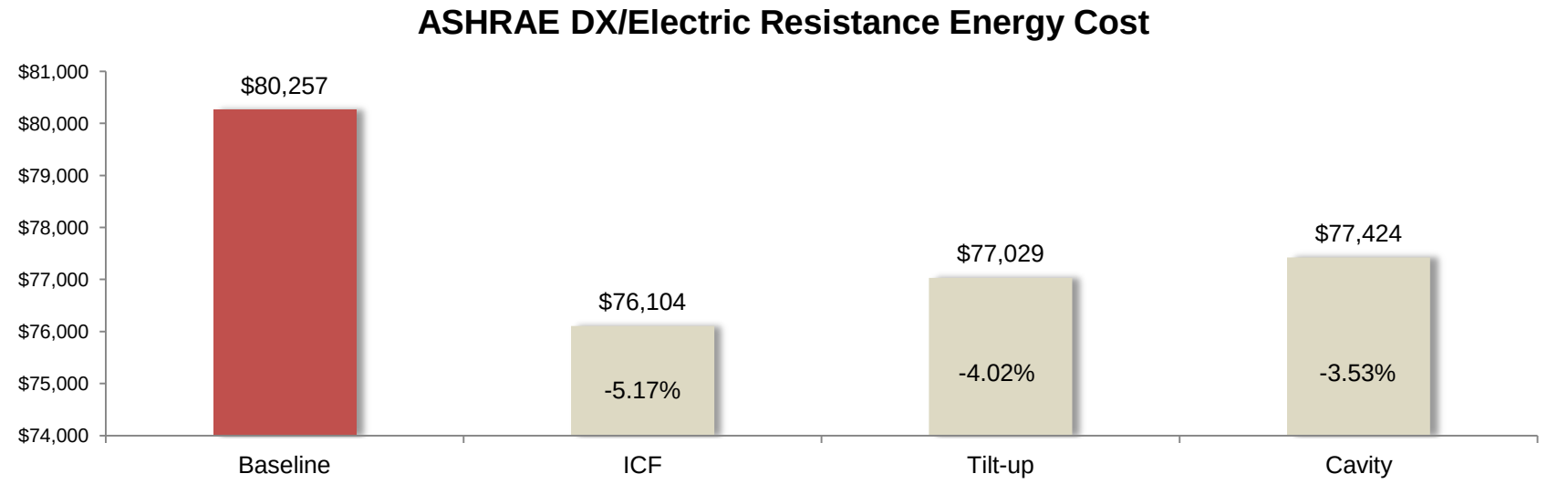
[ARC envelope | energy modeling | gas heat baseline]

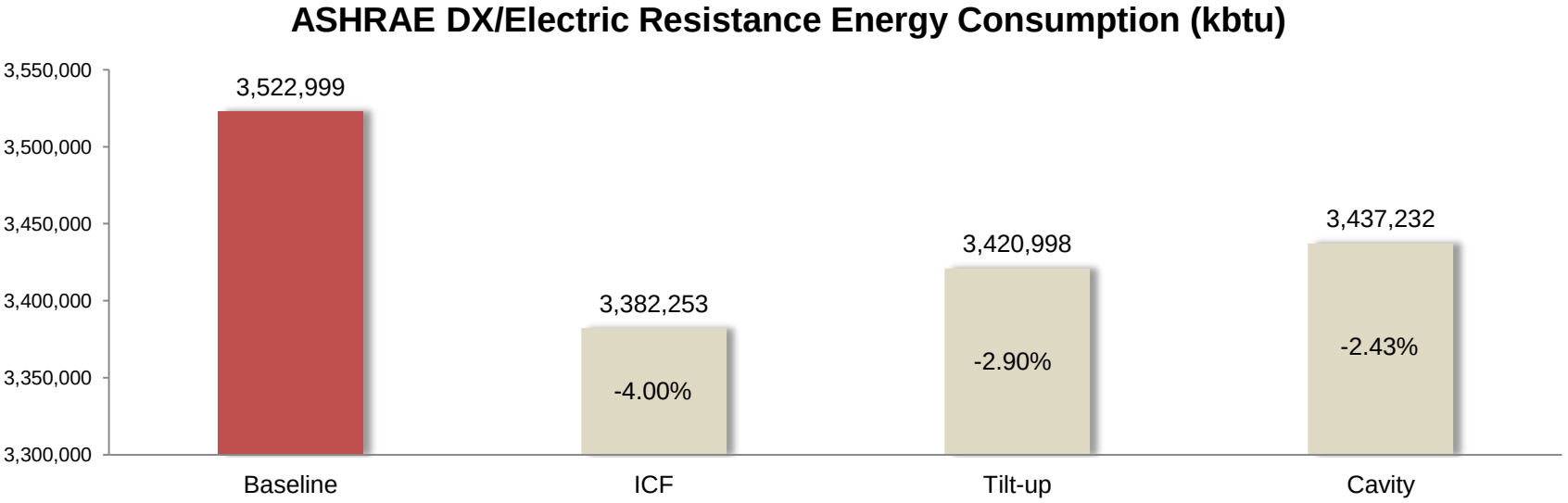




Building Envelope

[ARC envelope | energy modeling | electric heat baseline]





Building Envelope

[ARC envelope | life cycle cost]

Cost Component	Baseline Metal Frame ASHRAE DX/Hydronic	ICF ASHRAE DX/Hydronic	Tilt-Up Panel ASHRAE DX/Hydronic	CMU Cavity ASHRAE DX/Hydronic
Capital Cost	$ 0 (Do Nothing)	$ 191,291.00	$ 427,959.00	$ 189,014.00
Energy Consumption Costs	$ 1,792,748.00	$ 1,723,744.00	$ 1,740,499.00	$ 1,747,525.00
Energy Demand Costs	$ 1,142,808.00	$ 1,111,285.00	$ 1,111,090.00	$ 1,111,529.00
Subtotal (Future Cost Items)	$ 2,935,556.00	$ 2,835,029.00	$ 2,851,590.00	$ 2,859,054.00
50 Year PV Life Cycle Cost	**$ 2,935,556.00**	**$ 3,026,320.00**	**$ 3,279,549.00**	**$ 3,048,068.00**

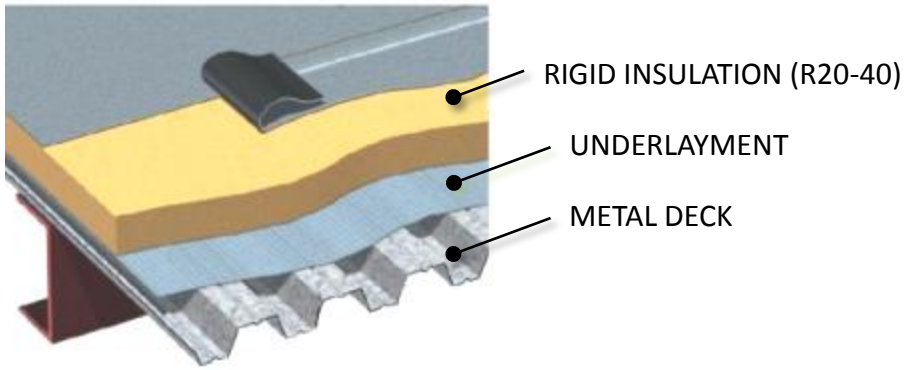
Cost Component	Baseline Metal Frame ASHRAE DX/Electric Resistance	ICF ASHRAE DX/Electric Resistance	Tilt-Up Panel ASHRAE DX/Electric Resistance	CMU Cavity ASHRAE DX/Electric Resistance
Capital Cost	$ 0 (Do Nothing)	$ 191,291.00	$ 427,959.00	$ 189,014.00
Energy Consumption Costs	$ 2,030,746.00	$ 1,938,659.00	$ 1,964,008.00	$ 1,974,630.00
Energy Demand Costs	$ 1,934,822.00	$ 1,821,253.00	$ 1,842,739.00	$ 1,852,142.00
Subtotal (Future Cost Items)	$ 3,965,568.00	$ 3,759,912.00	$ 3,806,747.00	$ 3,826,772.00
50 Year PV Life Cycle Cost	**$ 3,965,568.00**	**$ 3,951,203.00**	**$ 4,234,706.00**	**$ 4,015,786.00**

Payback: Year 47 (YES)

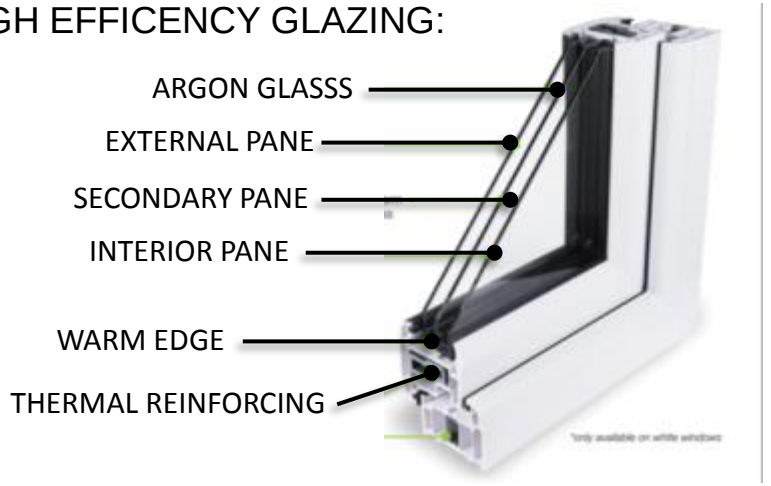
Building Envelope | OMS

[envelope components]

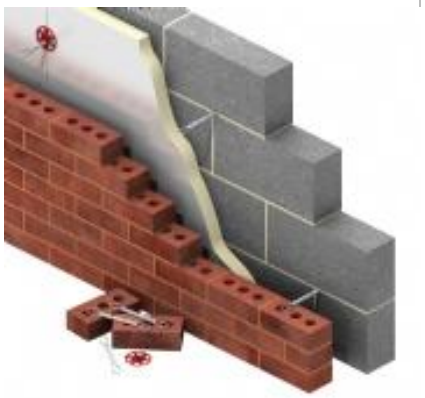
BUILT-UP ROOFING SYSTEM:



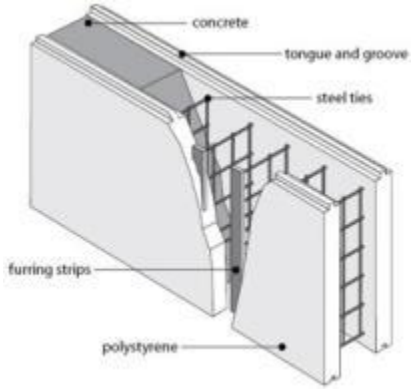
HIGH EFFICENCY GLAZING:



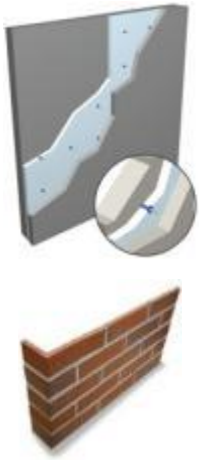
BRICK AND BLOCK CAVITY WALL:



ICF WALL SYSTEM:



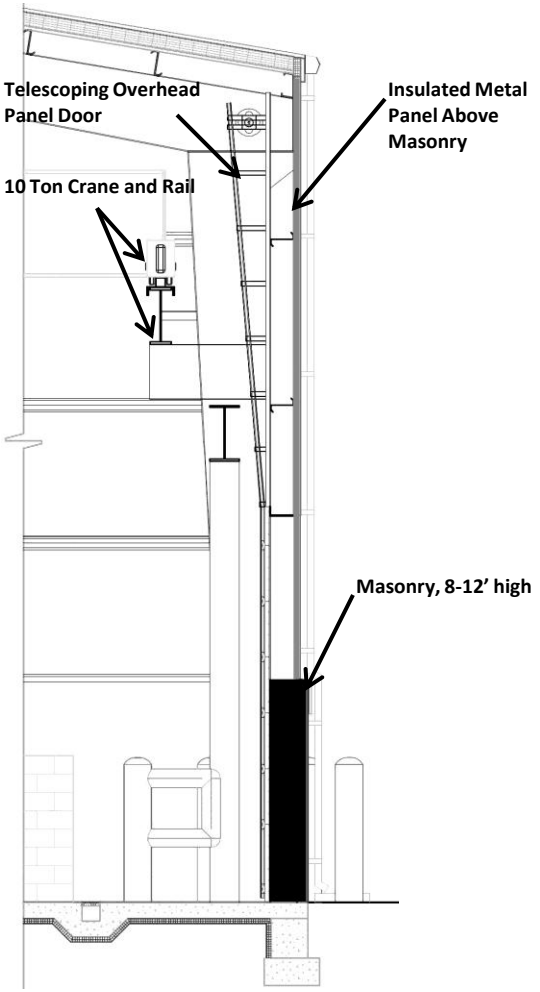
TILT-UP INSULATED PANEL SYSTEM:



INSULATED METAL PANEL SYSTEM (3”-4”):

Building Envelope | OMS

[envelope components]

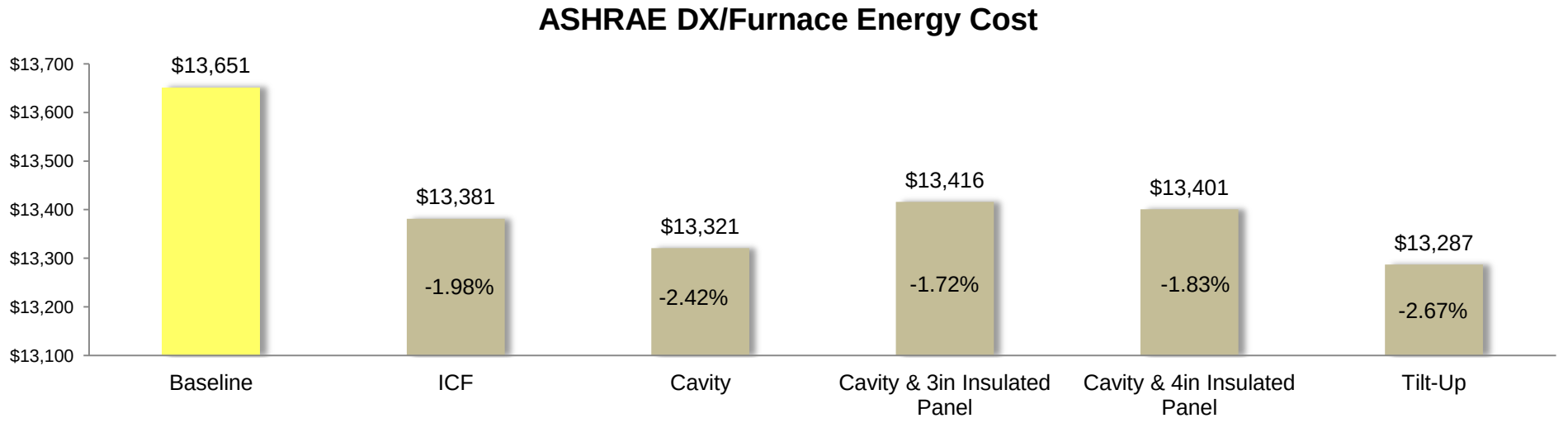


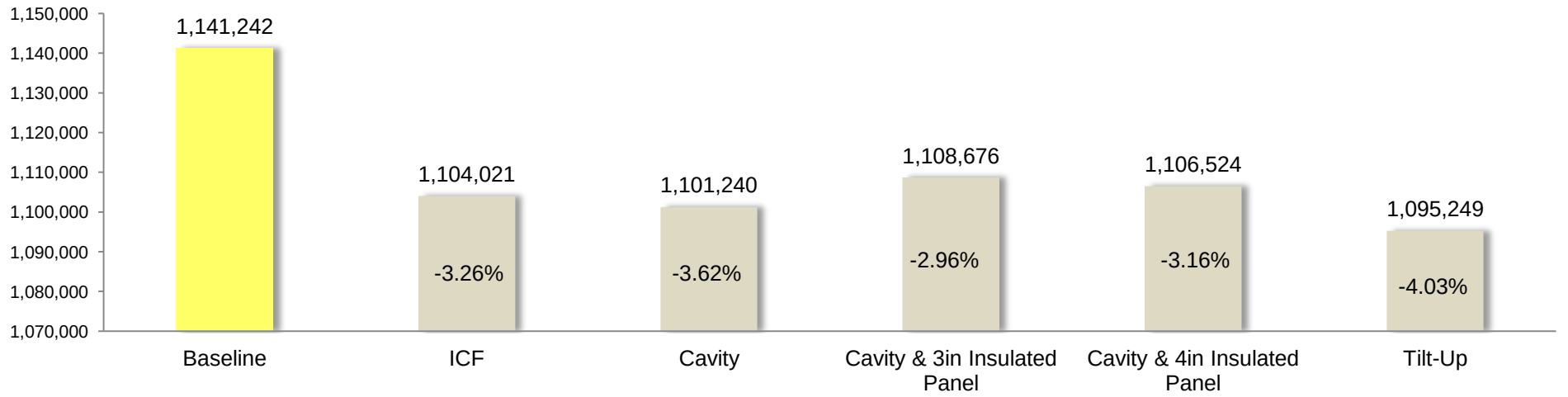
TEMF Maintenance Bay Section:
(Pre-Engineered Metal Structure/Building)

INSULATED METAL PANEL SYSTEM (3"-4"):

Building Envelope

[OMS envelope | energy modeling]





Building Envelope

[OMS envelope | life cycle cost]

	Baseline	ICF	CMU Cavity	CMU Cavity & 3in Insulated Panel	CMU Cavity & 4in Insulated Panel	Tilt-Up
Capital Cost	$ 0 (Do Nothing)	$ 35,234.00	$ 31,726.00	$ (106,673.00)	$ (101,906.00)	$ 89,246.00
Energy Consumption Costs	$ 476,662.00	$ 462,619.00	$ 461,294.00	$ 464,307.00	$ 463,486.00	$ 459,165.00
Energy Demand Costs	$ 202,389.00	$ 200,683.00	$ 199,124.00	$ 200,927.00	$ 200,878.00	$ 199,319.00
Subtotal (Future Cost Items)	$ 679,051.00	$ 663,302.00	$ 660,418.00	$ 665,234.00	$ 664,364.00	$ 658,484.00
50 Year PV Life Cycle Cost	**$ 679,051.00**	**$ 698,536.00**	**$ 692,144.00**	**$ 558,561.00**	**$ 562,458.00**	**$ 747,730.00**

Payback: Immediate (YES)

[Discussion & Decisions]

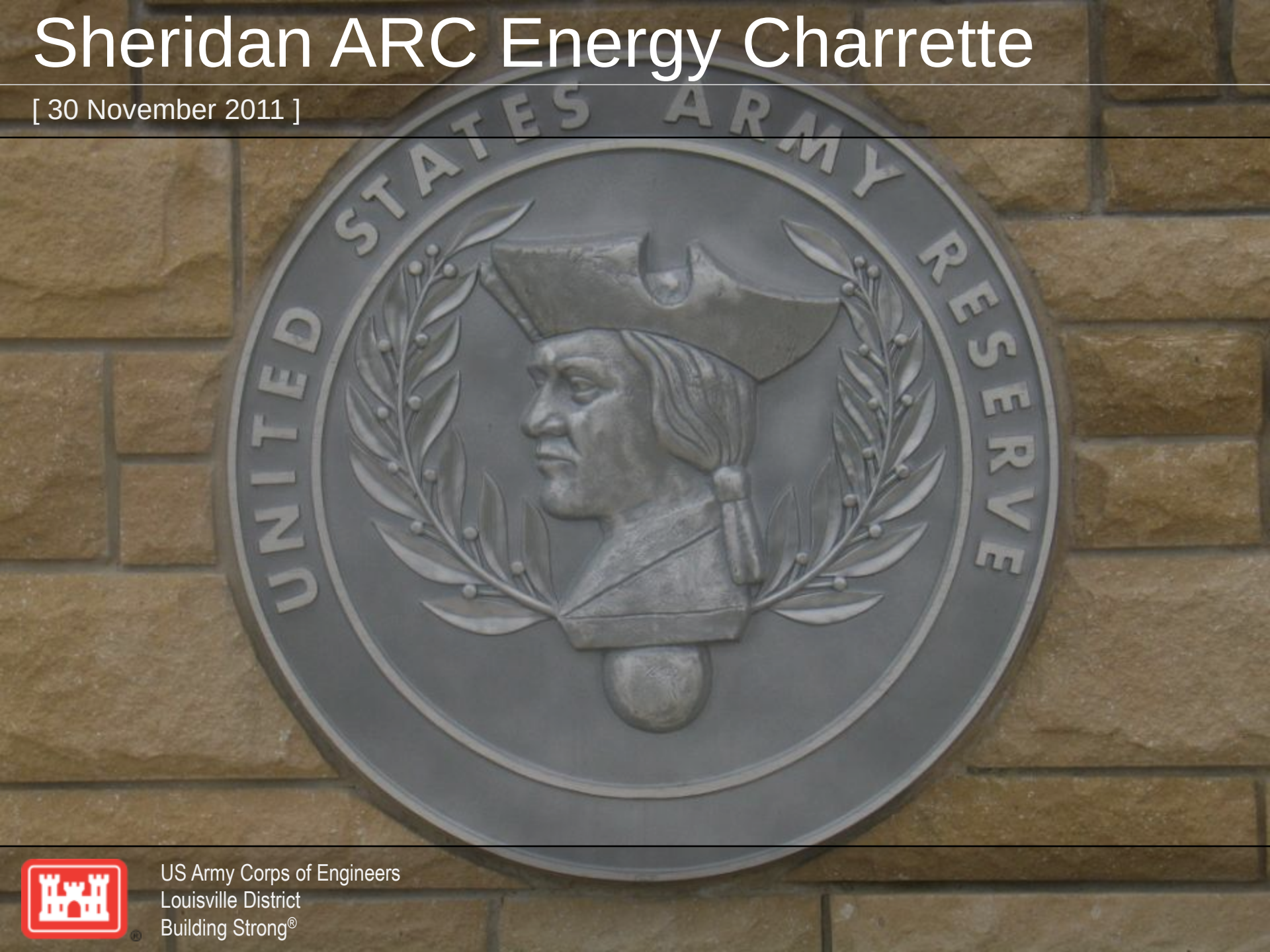
[Day 1 Conclusion]

Remarks:

- ARIM-D Project Officer
- USACE – Louisville District PM

Sheridan ARC Energy Charrette

[30 November 2011]



US Army Corps of Engineers
Louisville District
Building Strong®

[Day 1 Recap]

- USACE – Louisville District

Remarks:

- ARIM-D Project Officer
- USACE – Louisville District PM

Review Agenda

[summary]

Day 1 | Project Introduction + Establish Parameters

Goals + Process

Project Scope

Current Parameters | Governing Criteria

Site Constraints | Organization

Energy Modeling | Parameters + Assumptions

Building Envelope Study

Day 2 | Data Presentation + Integration

Updates: Site | Adjacencies

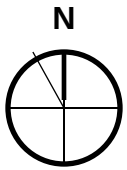
Energy Reduction + Conservation

Summarize Decisions | Discussion

Charrette Wrap-up | Way Ahead

Update Site

[overall site]



Site rotated 21.5° of due South

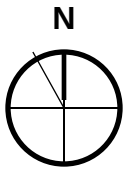
Optimum rotation for solar exposure:
5° of due South

LEGEND:

- PERIMETER FENCE (EXIST.)
- ATFP SETBACK - 148’-0”
- ATFP SETBACK - 82’-0”
- #1: TRNG BUILDABLE FOOTPRINT
- #2: OMS BUILDABLE FOOTPRINT
- #3: UHS BUILDABLE FOOTPRINT

Update Site

[ARC site]



Site rotated 21.5° of due South

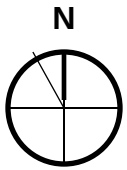
Optimum rotation for solar exposure:
5° of due South

LEGEND:

- PERIMETER FENCE (EXIST.)
- PROPOSED PV ARRAY FIELD (1,200 SF)
- PROPOSED GEOTHERMAL WELL FIELD (75,000 SF)

Update Site

[OMS site]



Site rotated 21.5° of due South

Optimum rotation for solar exposure:
5° of due South

LEGEND:

PERIMETER FENCE (EXIST.)

PROPOSED HARDSTAND

Update Adjacencies

[spatial programming | ARC]

1ST FLOOR:

Update Adjacencies

[spatial programming | ARC]

2ND FLOOR:

Update Adjacencies

[spatial programming | OMS]

1ST FLOOR

[15 Minute Break]

Energy Reduction + Conservation

[energy conserving measure categories]

BASE BID DESIGN (Planned)

- Required by current criteria.
- Planned to include.

INVESTIGATIVE STUDIES (Researched)

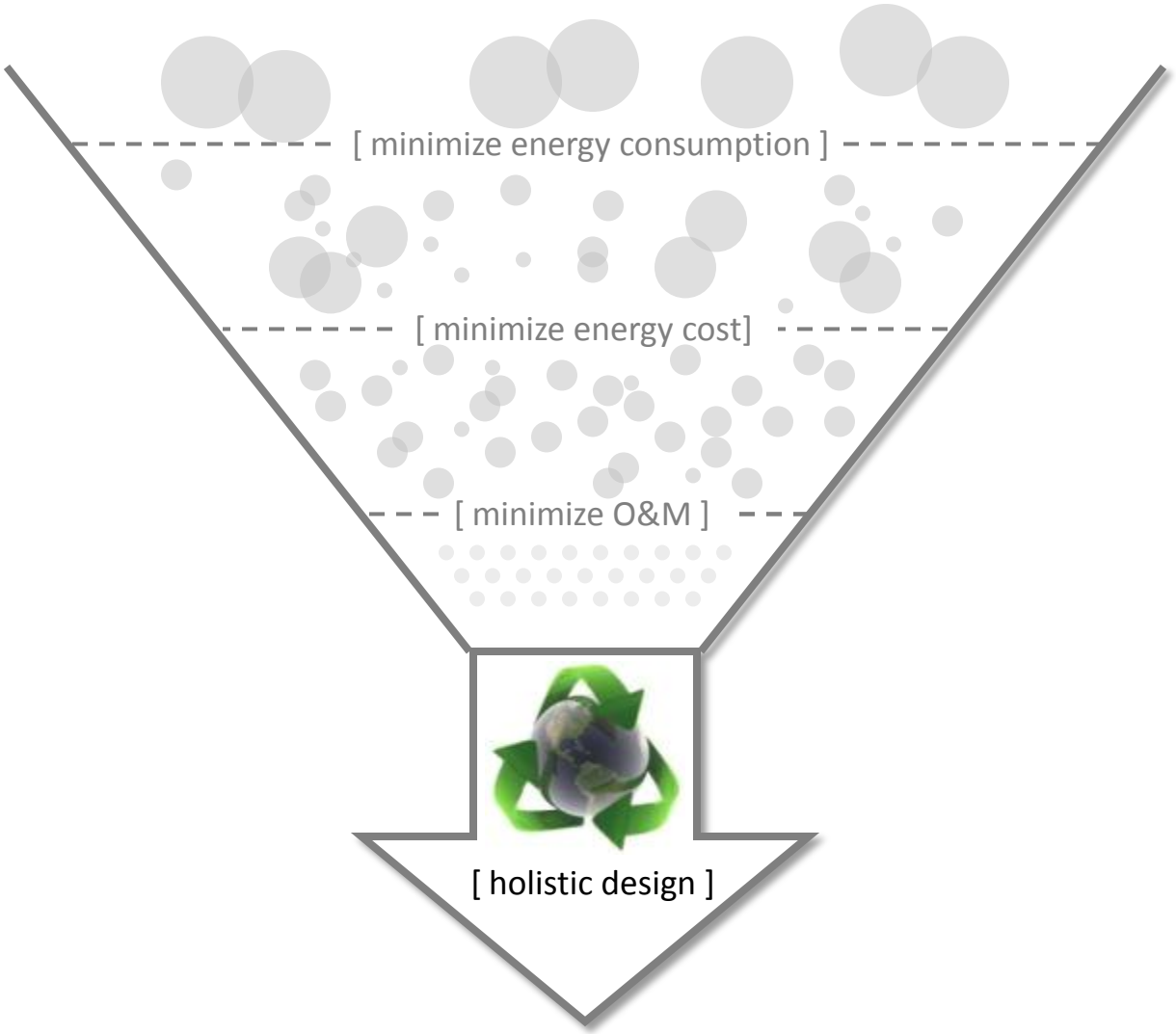
- Researched and presented for consideration based on Life Cycle Cost Analysis (LCCA).

FUTURE INVESTIGATION

- PDT to further investigate during design process.

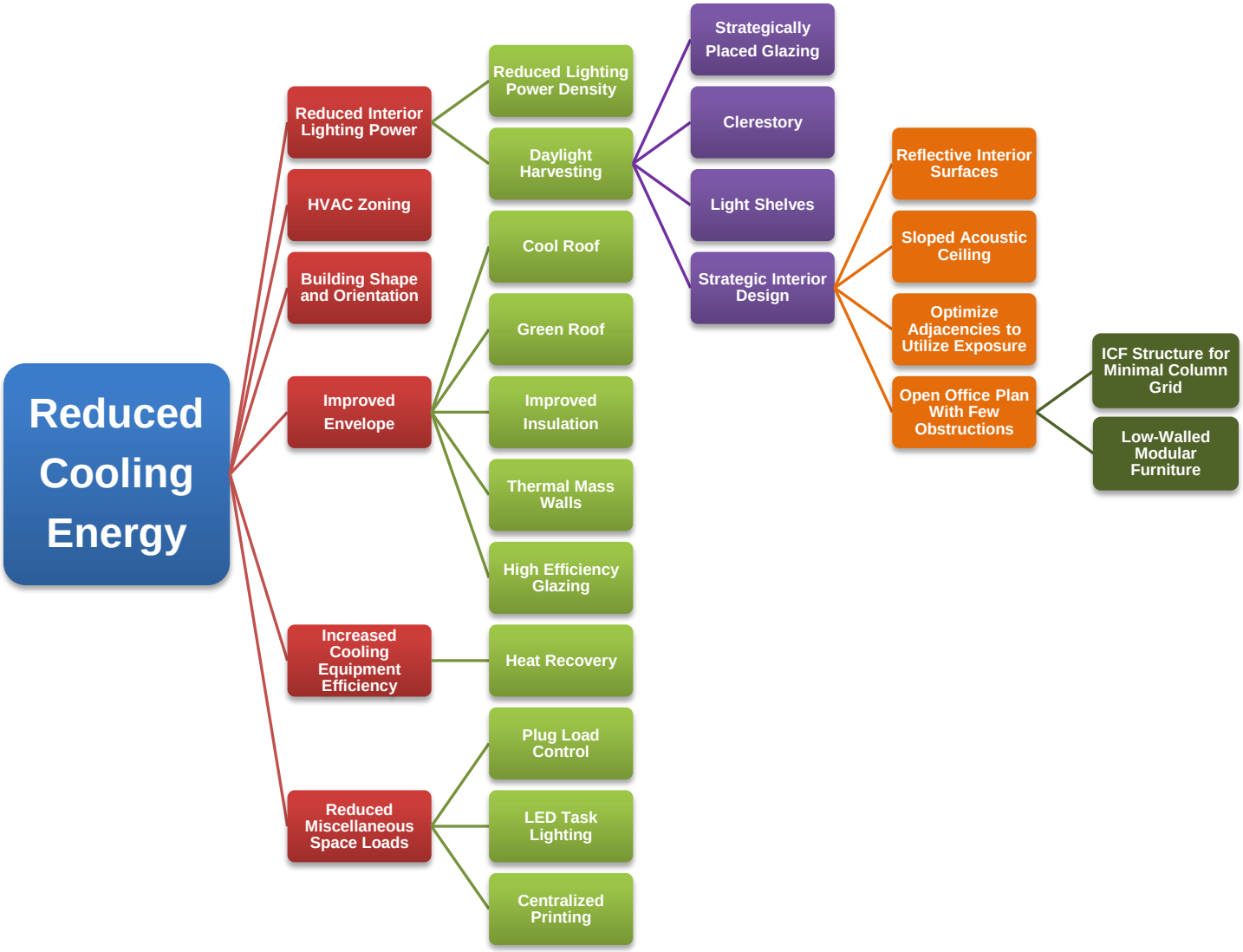
Energy Reduction + Conservation

[energy consuming systems | selection approach]



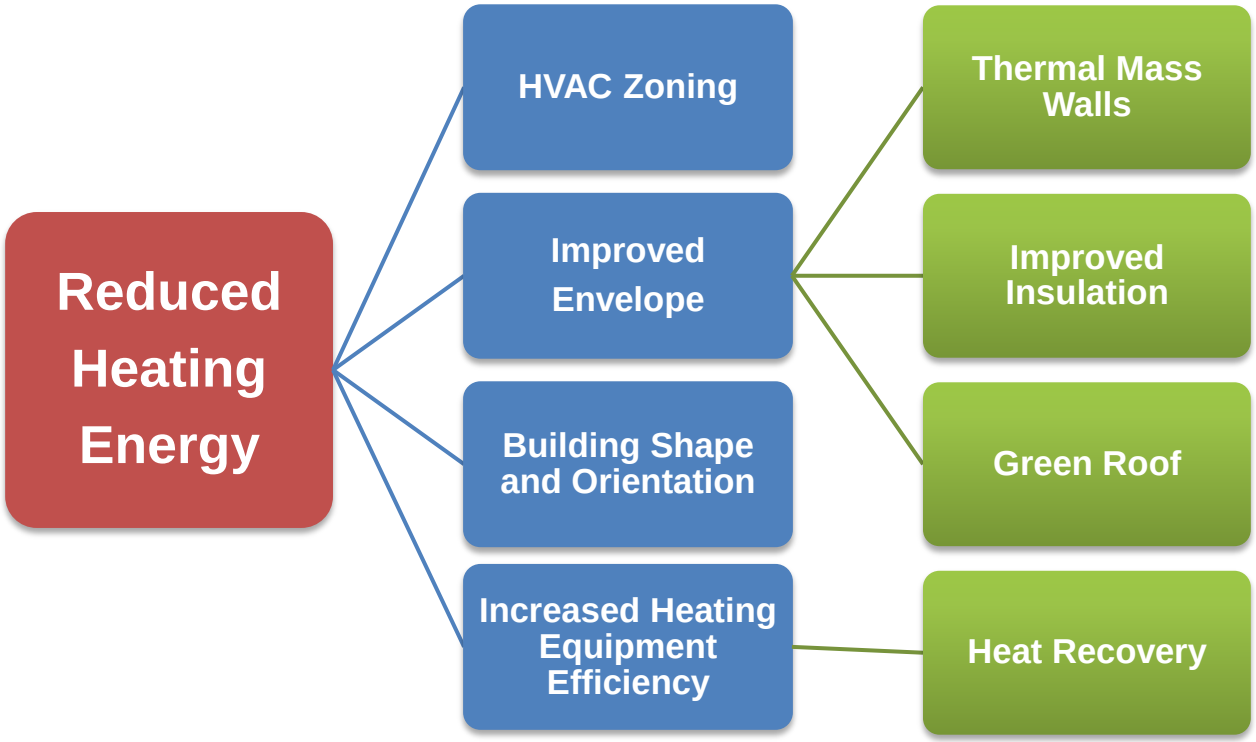
Energy Reduction + Conservation

[synergistic measures]



Energy Reduction + Conservation

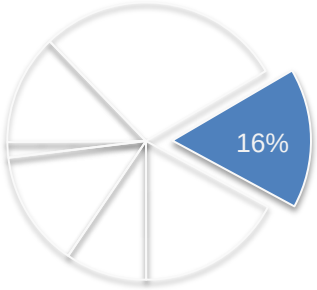
[synergistic measures]



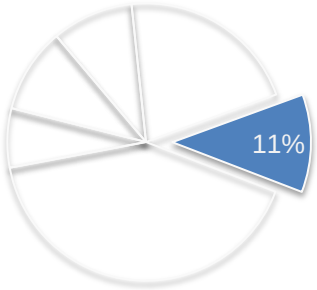
Energy Reduction + Conservation

[energy conserving measures | space cooling]

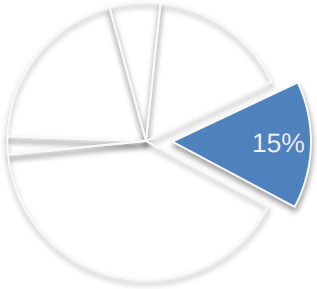
ARC
DX Cooling
Gas Heating
Baseline



ARC
DX Cooling
Electric Heating
Baseline



OMS
DX Cooling
Gas Heating
Baseline



BASE BID DESIGN (Planned)

- Improved HVAC efficiency
- Heat recovery
- Cool roof
- Variable frequency drives
- Thermal mass envelope
- Improved envelope insulation
- Building shape
- HVAC zoning
- Plug load control
- High efficiency glazing
- Centralized Printing

INVESTIGATIVE STUDIES (Researched)

- Full Ground Source Heat Pump
- Variable Refrigerant Volume
- Four Pipe Fan Coil
- Variable Air Volume
- Water Source Heat Pump

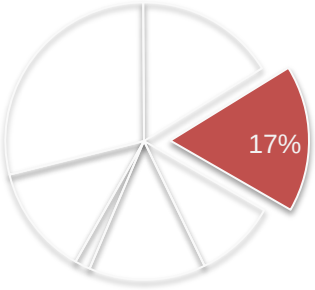
FUTURE INVESTIGATION

- Ice Storage
- Hybrid Ground Source Heat Pump
- Chilled Beam

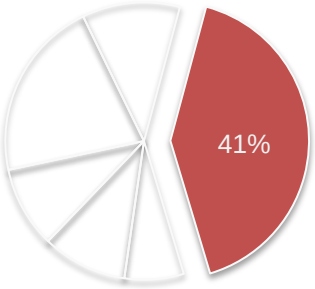
Energy Reduction + Conservation

[energy conserving measures | space heating]

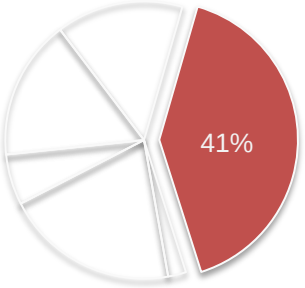
ARC
DX Cooling
Gas Heating
Baseline



ARC
DX Cooling
Electric Heating
Baseline



OMS
DX Cooling
Gas Heating
Baseline



BASE BID DESIGN (Planned)

- Improved HVAC efficiency
- Heat recovery
- Variable frequency drives
- Thermal mass envelope
- Improved envelope insulation
- Building shape
- HVAC zoning

INVESTIGATIVE STUDIES (Researched)

- Full Ground Source Heat Pump
- Variable Refrigerant Volume
- Four Pipe Fan Coil
- Variable Air Volume
- Water Source Heat Pump
- Solar Wall
- In-floor radiant heat

FUTURE INVESTIGATION

- Hybrid Ground Source Heat Pump
- Green Roof

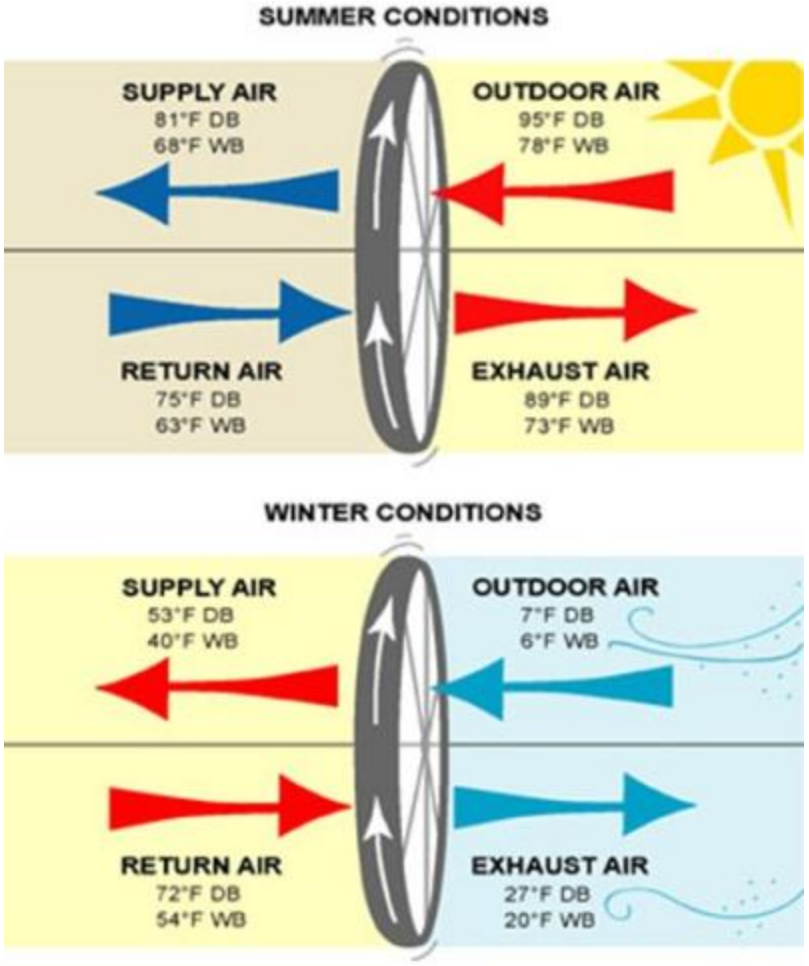
Energy Reduction + Conservation | HVAC

[energy recovery ventilator | system features]

Energy Recovery Ventilator

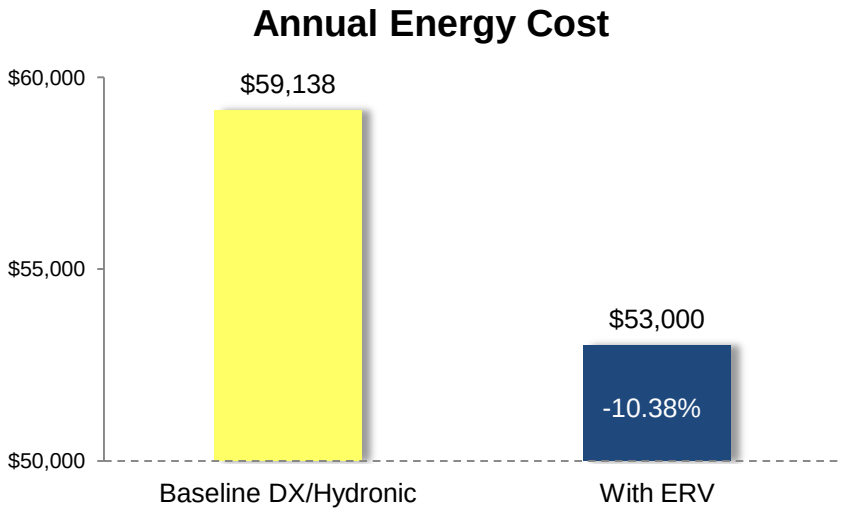
Transfers energy between the building exhaust/relief air and the incoming outdoor air.

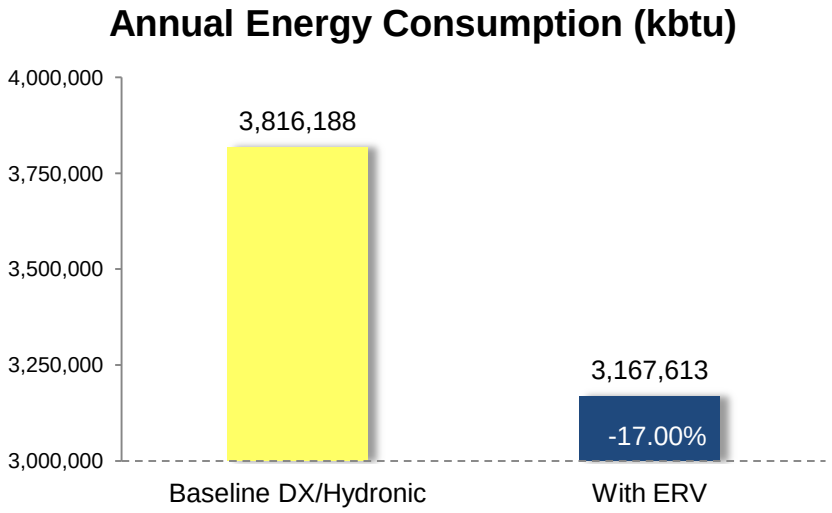
Can be used in-line with the proposed HVAC system or as a standalone Dedicated Outdoor Air System.



Energy Reduction + Conservation | HVAC

[energy recovery ventilator | life cycle cost | gas heat baseline]





Cost Component	Baseline DX/Hydronic	Baseline DX/Hydronic With Energy Recovery Ventilator	Savings
Capital Cost	$ 1,151,272.00*	$ 1,246,823.00*	$ (95,551.00)
Energy Consumption Costs	$ 1,266,008.00	$ 1,138,877.00	$ 91,019.00
Energy Demand Costs	$ 824,828.00	$ 736,353.00	$ 165,943.00
Annual Recurring OM&R Costs	$ 598,412.00 **	$ 598,412.00 **	$ -
Subtotal (Future Cost Items)	$ 2,689,248.00	$ 2,473,641.00	$ 256,962.00
40 Year PV Life Cycle Cost	**$ 3,840,520.00**	**$ 3,720,464.00**	**$ 120,056.00**

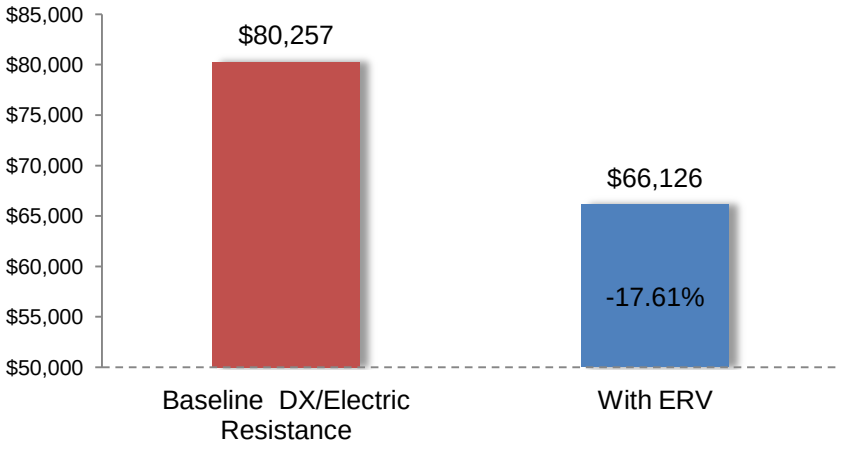
* Cost from LRL Cost Estimating
** Cost from historical data

Payback: Year 17 (YES)

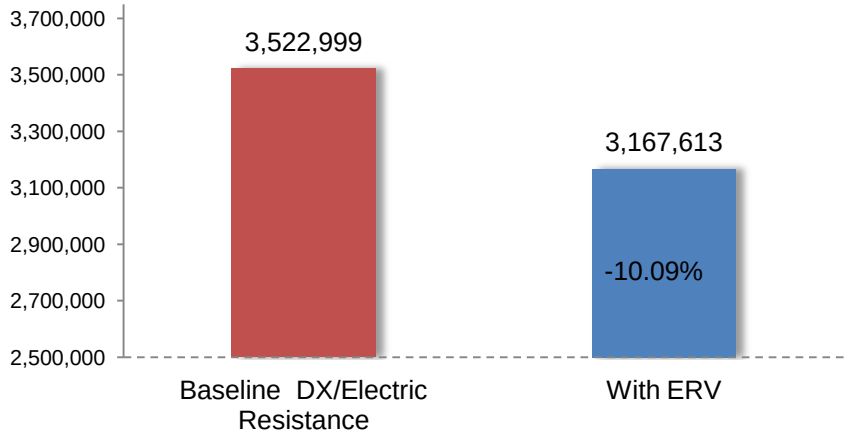
Energy Reduction + Conservation | HVAC

[energy recovery ventilator | life cycle cost | electric heat baseline]

Annual Energy Cost



Annual Energy Consumption (kbtu)



Cost Component	Baseline DX/Electric Resistance	Baseline DX/Electric Resistance With Energy Recovery Ventilator	Savings
Capital Cost	$ 929,307.00 *	$ 1,024,858.00*	$ (95,551.00)
Energy Consumption Costs	$ 1,454,825.00	$ 1,287,000.00	$ 167,825.00
Energy Demand Costs	$ 1,396,468.00	$ 1,062,718.00	$ 333,750.00
Annual Recurring OM&R Costs	$ 411,400.00 **	$ 411,400.00 **	$ -
Subtotal (Future Cost Items)	$ 3,262,693.00	$ 2,761,118.00	$ 501,575.00
40 Year PV Life Cycle Cost	**$ 4,192,000.00**	**$ 3,785,976.00**	**$ 406,024.00**

* Cost from LRL Cost Estimating
** Cost from historical data

Payback: Year 7 (YES)

Energy Reduction + Conservation | HVAC

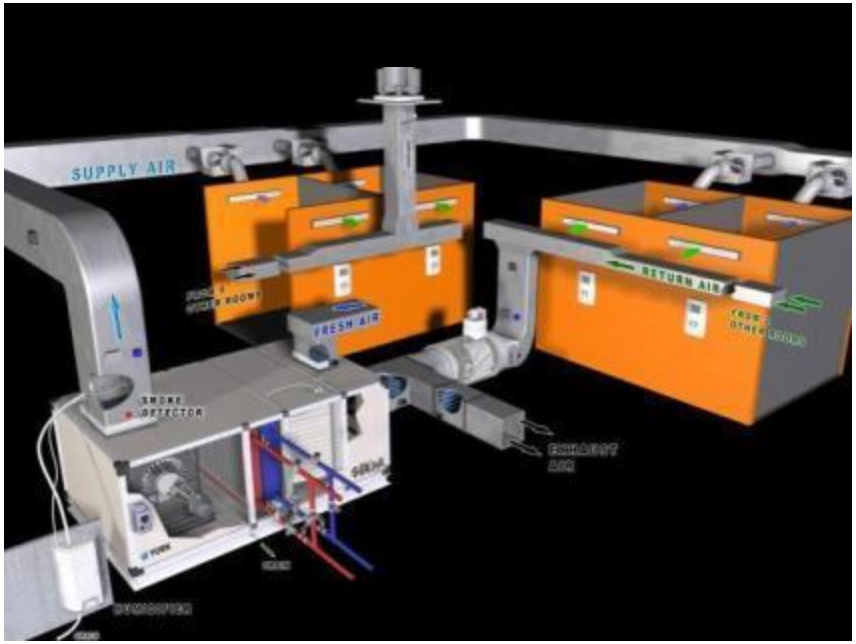
[variable air volume | system features]

Variable Air Volume System With ERV

Most common system type for office buildings

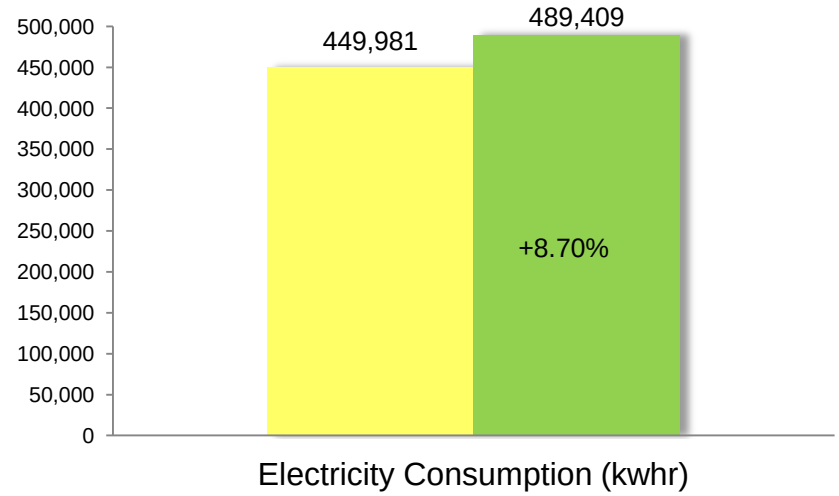
Regulates airflow quantity and temperature per cooling/heating demand and/or occupancy

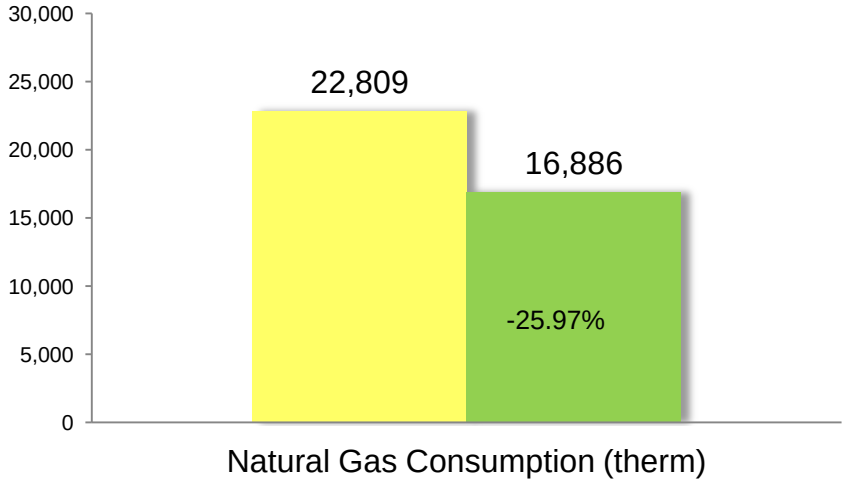
Versatile water system can be ground coupled, paired with high efficiency chiller/boiler, or can include ice/thermal storage system

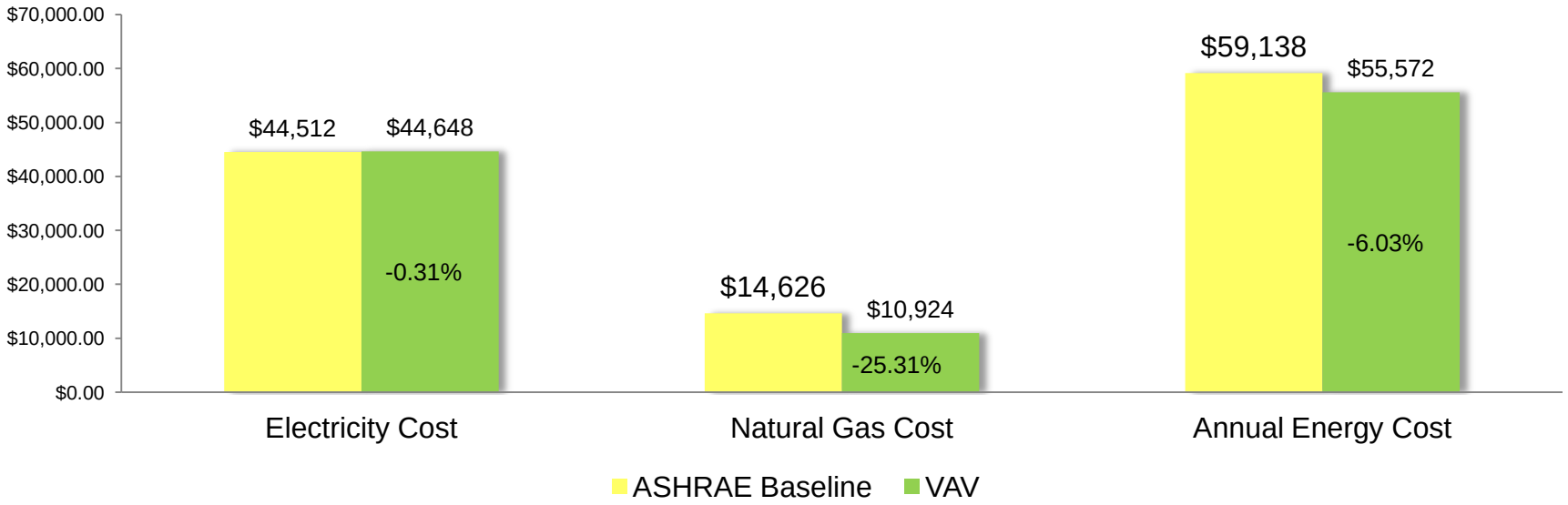


Energy Reduction + Conservation | HVAC

[variable air volume | energy modeling]







Energy Reduction + Conservation | HVAC

[variable air volume | life cycle cost]

Cost Component	ASHRAE DX/Hydronic Baseline System	Variable Air Volume System	Savings
Capital Cost	$ 1,151,272.00 *	$ 1,412,471.00 *	$ (261,199.00)
Energy Consumption Costs	$ 1,266,008.00	$ 1,188,574.00	$ 77,434.00
Energy Demand Costs	$ 824,828.00	$ 773,592.00	$ 51,235.00
Annual Recurring OM&R Costs	$ 598,412.00 **	$ 822,799.00 **	$ (224,387.00)
Subtotal (Future Cost Items)	$ 2,689,248.00	$ 2,784,966.00	$ (95,718.00)
40 Year PV Life Cycle Cost	**$ 3,840,520.00**	**$ 4,197,437.00**	**$ (356,917.00)**

* Cost from LRL Cost Estimating

** Cost from historical data

Payback: NO

LEED Percentage	EPAct Percentage
6.03% (Energy Cost Savings)	17.27% (Energy Savings)

Energy Reduction + Conservation | HVAC

[four pipe fan coil | system features]

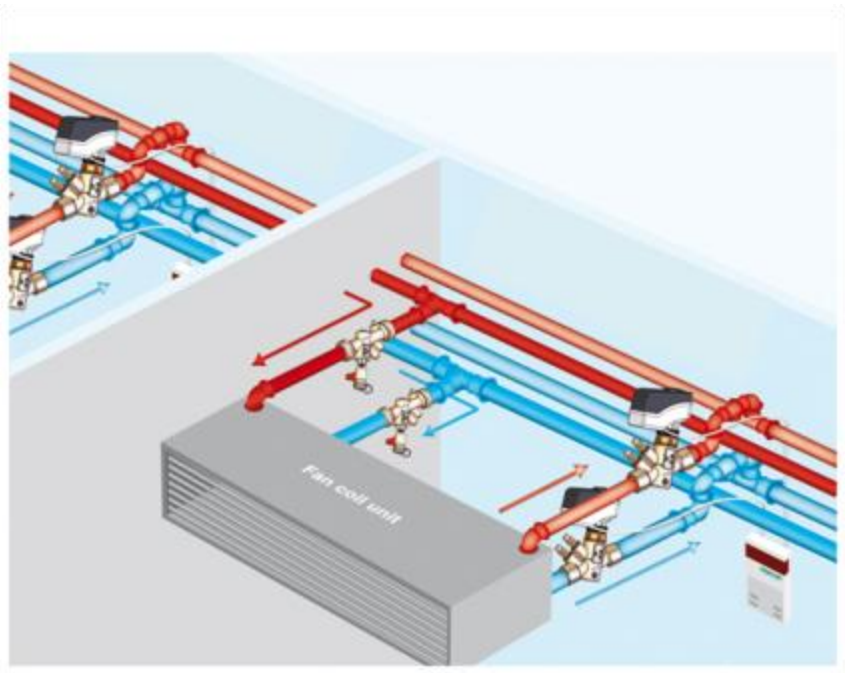
Four Pipe Fan Coil System With DOAS

Reduces fan energy by distributing circulation fans; zone fans run only when heating or cooling is required.

Couples with a true Dedicated Outdoor Air System to deliver ventilation air directly to spaces.

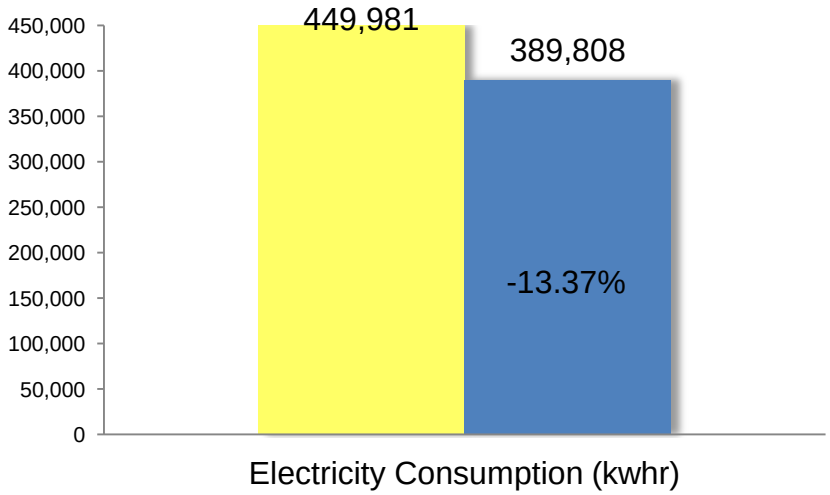
Flexible terminal unit selection; large, ducted, multi-space zone units or small single-space units.

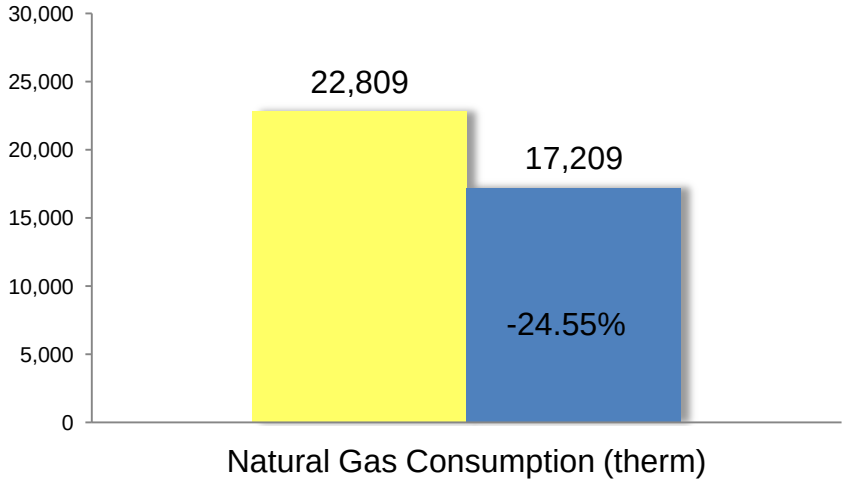
Versatile water system can be ground coupled, paired with high efficiency chiller/boiler, or can include ice/thermal storage system.

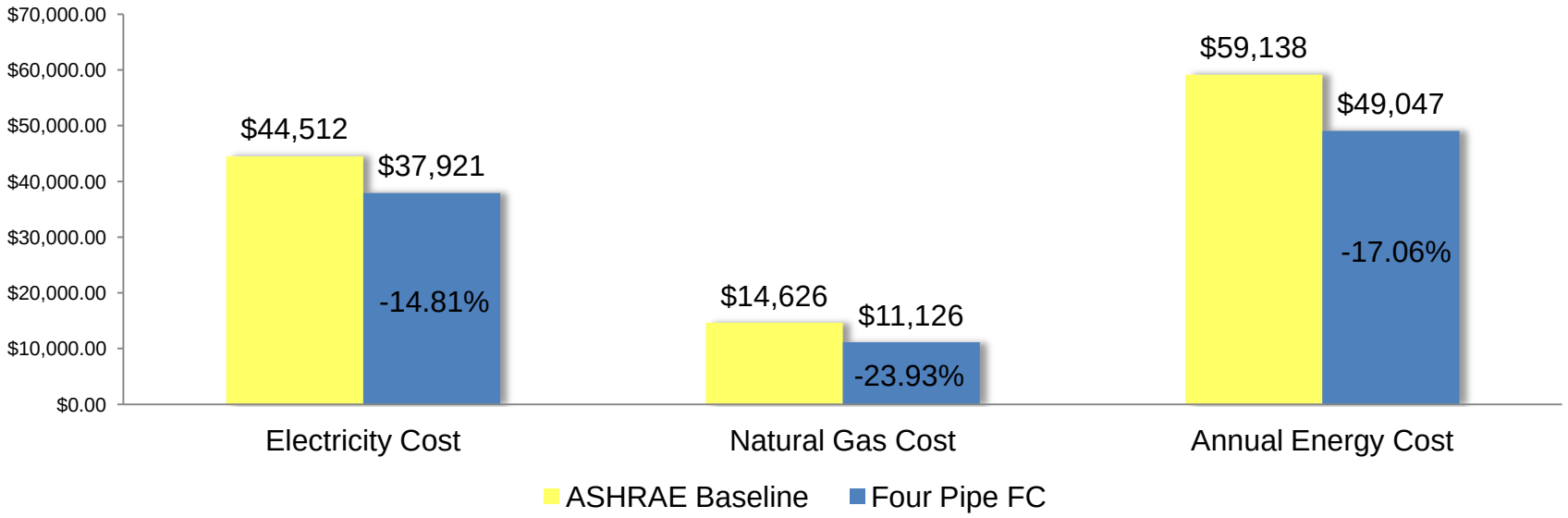


Energy Reduction + Conservation | HVAC

[four pipe fan coil | energy modeling]







Energy Reduction + Conservation | HVAC

[four pipe fan coil | life cycle cost]

Cost Component	ASHRAE DX/Hydronic Baseline System	Four Pipe Fan Coil System	Savings
Capital Cost	$ 1,151,272.00 *	$ 1,282,014.00*	$ (130,742.00)
Energy Consumption Costs	$ 1,266,008.00	$ 1,036,236.00	$ 229,772.00
Energy Demand Costs	$ 824,828.00	$ 693,592.00	$ 131,235.00
Annual Recurring OM&R Costs	$ 598,412.00 **	$ 897,618.00 **	$ (299,206.00)
Subtotal (Future Cost Items)	$ 2,689,248.00	$ 2,627,446.00	$ 61,802.00
40 Year PV Life Cycle Cost	**$ 3,840,520.00**	**$ 3,909,460.00**	**$ (68,940.00)**

* Cost from LRL Cost Estimating
** Cost from historical data

Payback: NO

LEED Percentage	EPAct Percentage
17.06% (Energy Cost Savings)	28.81% (Energy Savings)

Energy Reduction + Conservation | HVAC

[ice/thermal energy storage | system features]

Ice / Thermal Energy Storage System

Reduces energy cost with time-of-day utility charges by shifting mechanical cooling to off-peak hours.

May reduce energy consumption by allowing a smaller chiller to operate nearer its peak efficiency.

Can be sized to satisfy all or part of the building cooling load.

Coupled with Variable Air Volume or Four Pipe Fan Coil systems, could drastically change life cycle cost effectiveness.

Note: Current In-house Modeling software does not support analysis of system. Further research is required.

Energy Reduction + Conservation | HVAC

[ground source heat pumps | system features]

Ground Source Heat Pump System With ERV

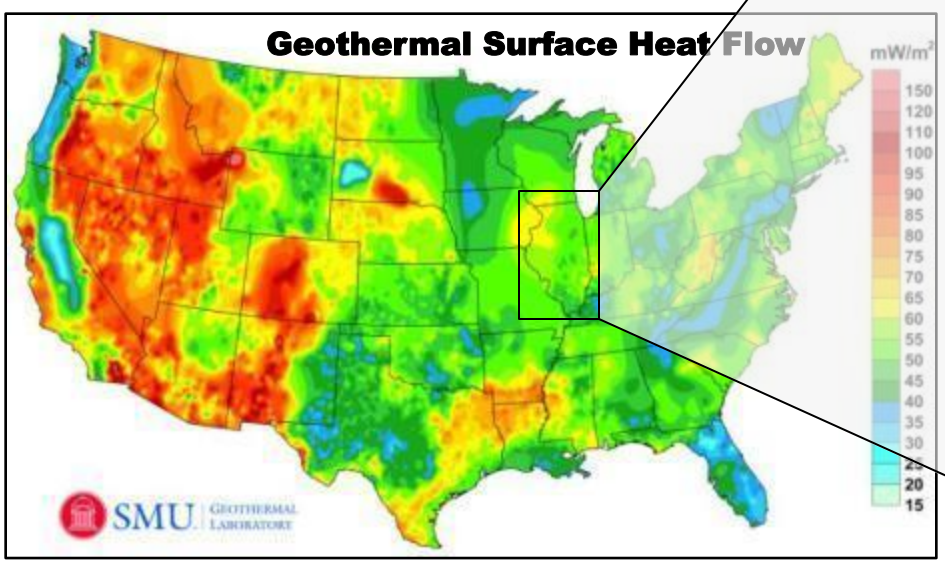
Uses the Earth as a source/sink for heat in heating/cooling modes of operation

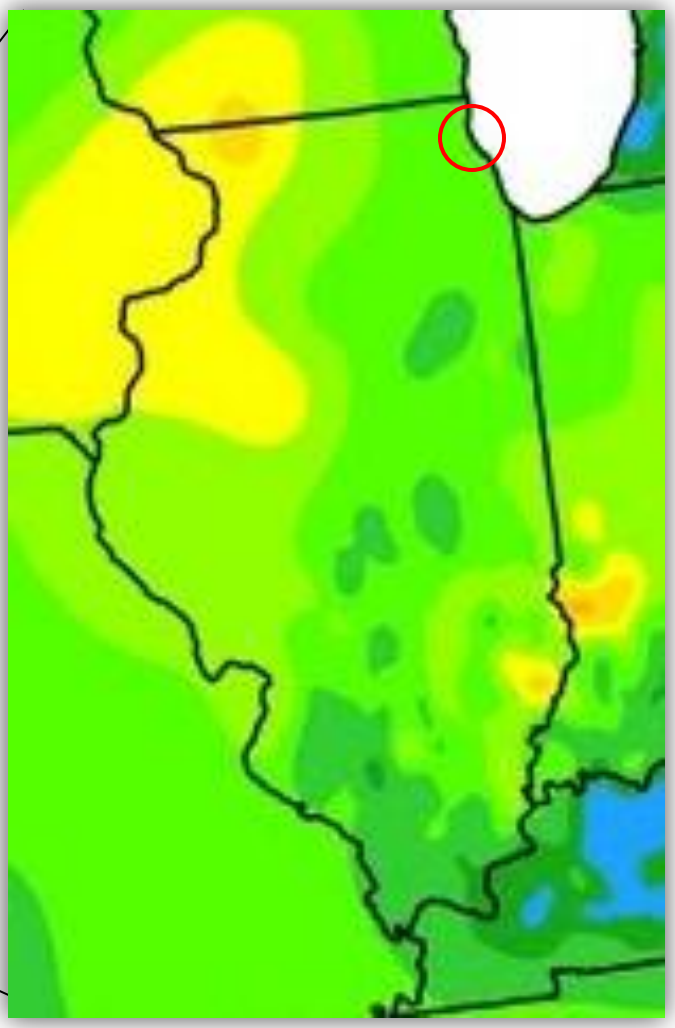
Operates at highest efficiency during call for both heating and cooling, as ground loop temperature is maintained

Requires minimal maintenance, as no major central plant equipment is required

Energy Reduction + Conservation | HVAC

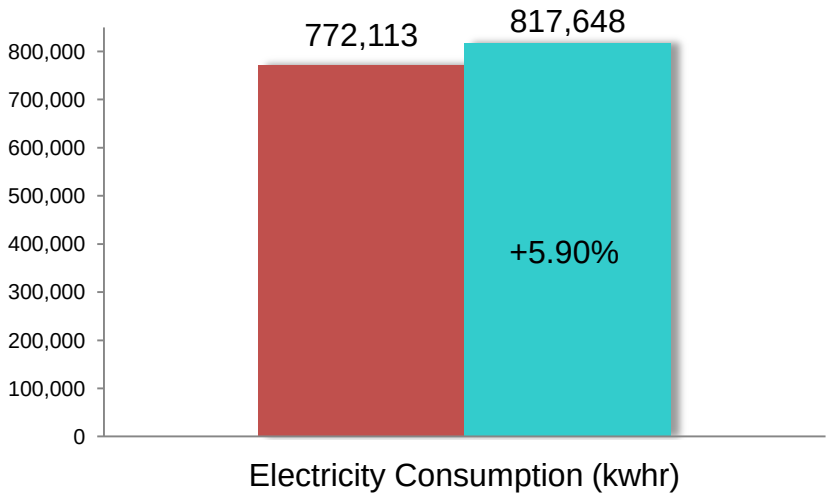
[renewable energy | regional context | geothermal]

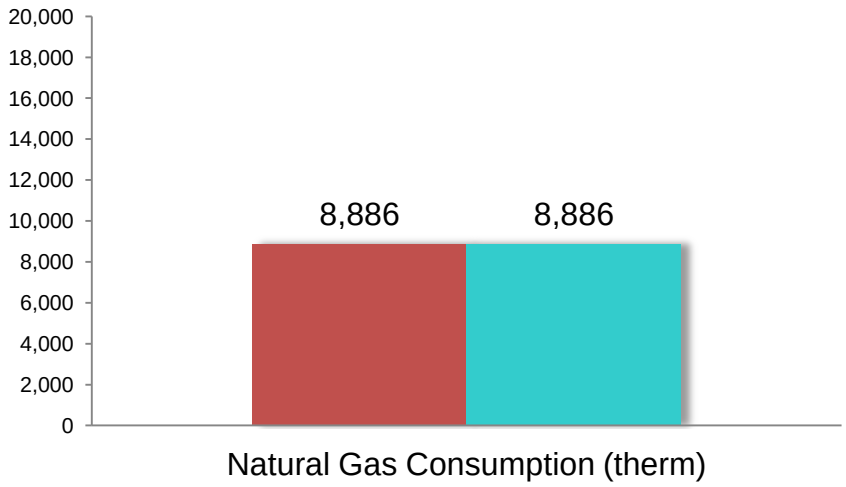


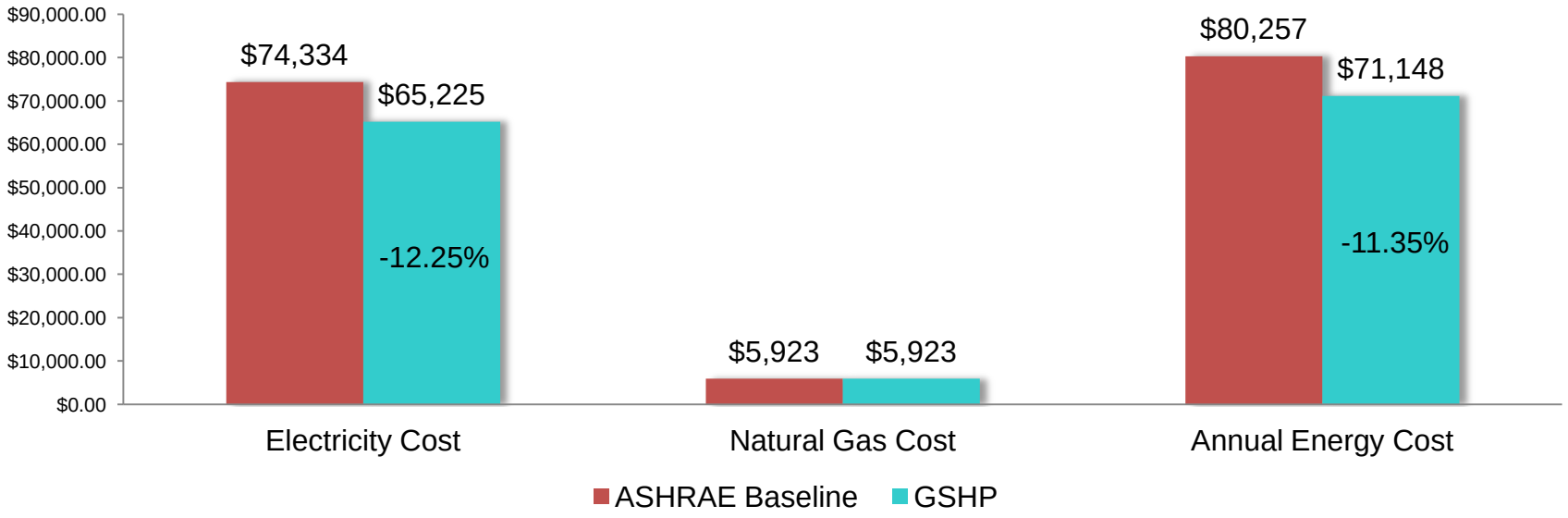


Energy Reduction + Conservation | HVAC

[ground source heat pumps | energy modeling]







Energy Reduction + Conservation | HVAC

[ground source heat pumps | life cycle cost]

Cost Component	ASHRAE DX/Electric Resistance Baseline System	Ground Source Heat Pump System	Savings
Capital Cost	$ 929,307.00 *	$ 1,547,362.00 **	$ (618,055.00)
Energy Consumption Costs	$ 1,454,825.00	$ 1,528,194.00	$ (73,369)
Energy Demand Costs	$ 1,396,468.00	$ 982,120.00	$ 414,348.00
Annual Recurring OM&R Costs	$ 411,400.00 **	$ 448,809.00 **	$ (37,410.00)
Subtotal (Future Cost Items)	$ 3,262,693.00	$ 2,959,123.00	$ 303,570.00
40 Year PV Life Cycle Cost	**$ 4,192,000.00**	**$ 4,506,485.00**	**$ (314,485.00)**

* Cost from LRL Cost Estimating
** Cost from historical data

Payback: NO

LEED Percentage	EPAct Percentage
11.35% (Energy Cost Savings)	-6.58% (Energy Savings)

Energy Reduction + Conservation | HVAC

[water source heat pumps | system features]

Water Source Heat Pump System With ERV

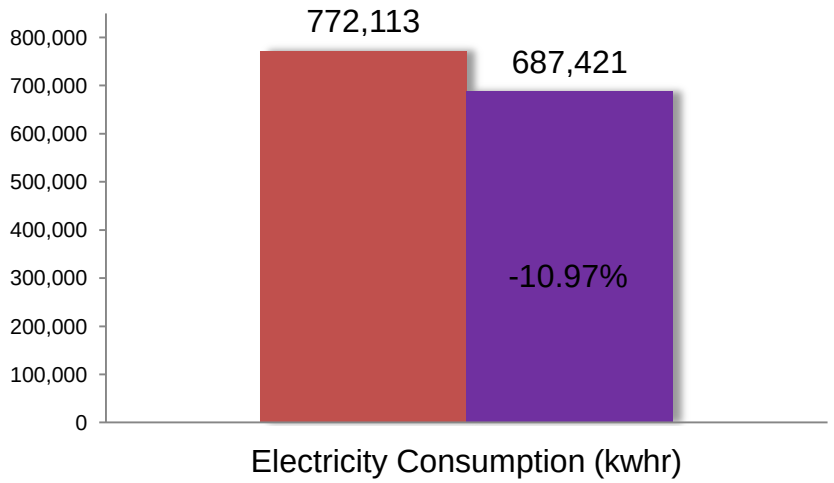
Utilizes boilers and cooling towers to add heat to or remove it from the building water loop.

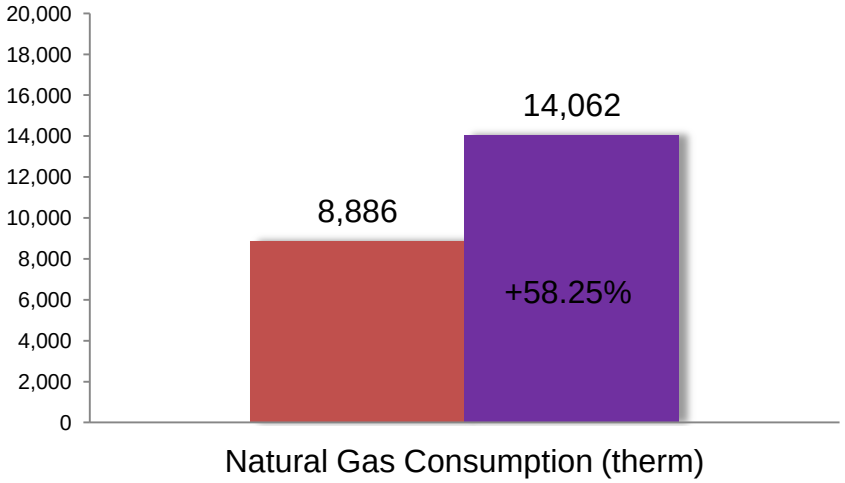
Operates at highest efficiency during both heating and cooling, as boiler/tower may not be required.

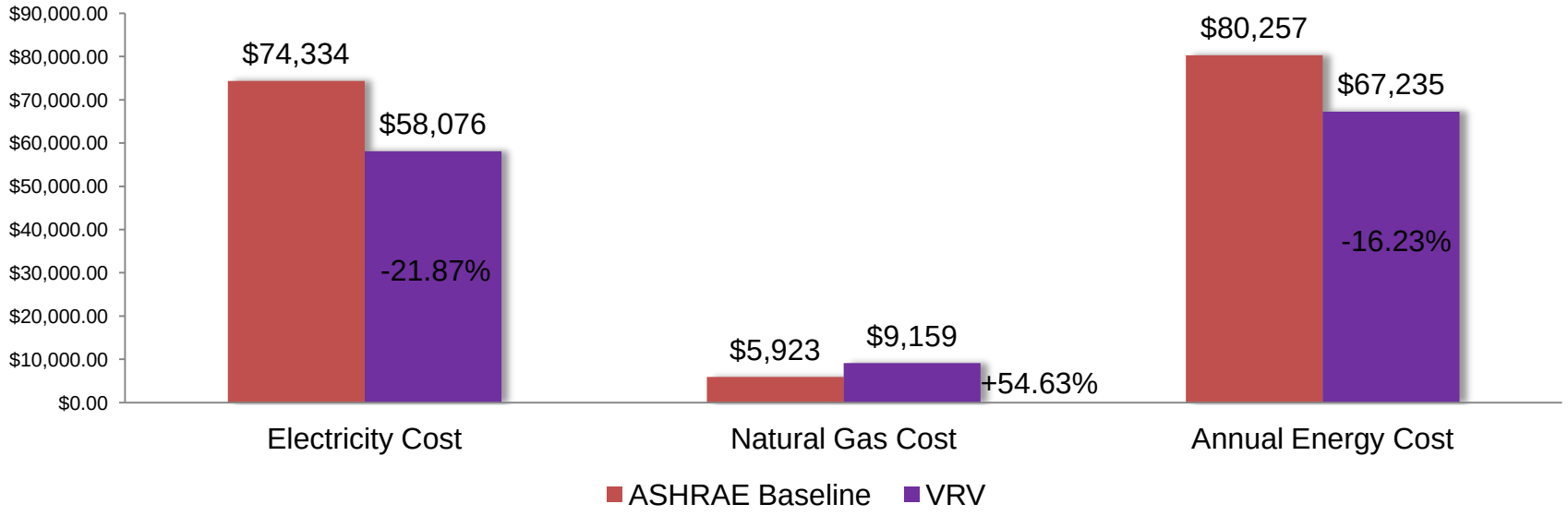
Reduced installation cost vs. ground source heat pumps.

Energy Reduction + Conservation | HVAC

[water source heat pumps | energy modeling]







Energy Reduction + Conservation | HVAC

[water source heat pumps | life cycle cost]

Cost Component	ASHRAE DX/Electric Resistance Baseline System	Water Source Heat Pump System	Savings
Capital Cost	$ 929,307.00 *	$ 1,357,335.00 **	$ (428,028.00)
Energy Consumption Costs	$ 1,454,825.00	$ 1,441,127.00	$ 13,698.00
Energy Demand Costs	$ 1,396,468.00	$ 931,377.00	$ 465,091.00
Annual Recurring OM&R Costs	$ 411,400.00 **	$ 897,618.00 **	$ (486,219.00)
Subtotal (Future Cost Items)	$ 3,262,693.00	$ 3,270,122.00	$ (7,429.00)
40 Year PV Life Cycle Cost	**$ 4,192,000.00**	**$ 4,627,457.00**	**$ (435,457.00)**

* Cost from LRL Cost Estimating
** Cost from historical data

Payback: NO

LEED Percentage	EPAct Percentage
16.23% (Energy Cost Savings)	-9.68% (Energy Savings)

Energy Reduction + Conservation | HVAC

[hybrid ground source heat pumps | system features]

Hybrid Ground Source Heat Pump System

Uses the Earth as a source/sink for heat in part load heating/cooling modes of operation; additional heat is added to or removed from the building water loop with by a boiler or cooling tower.

Operates at highest efficiency during call for both heating and cooling, as water loop temperature is maintained and boiler/tower may not be required.

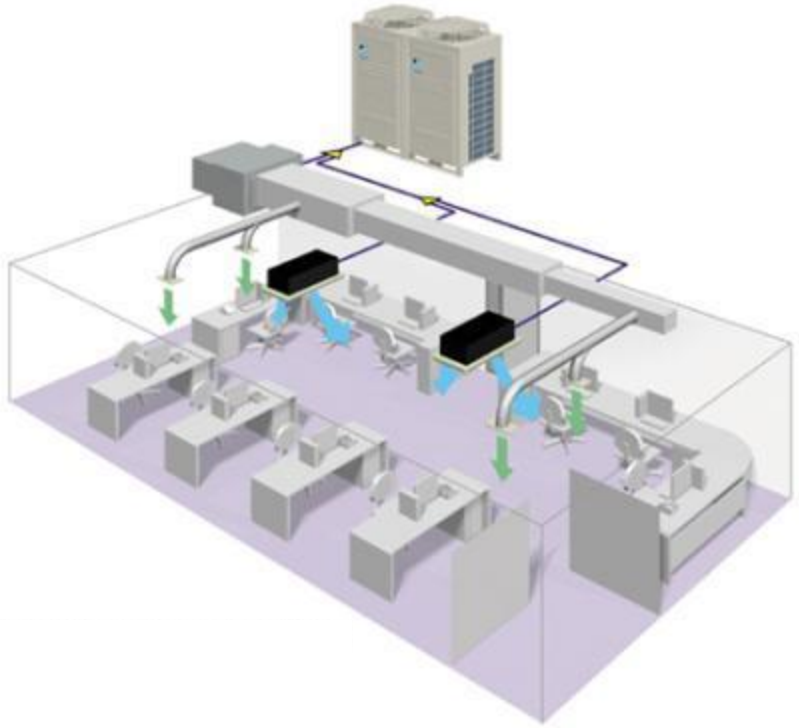
Note: Current In-house Modeling software does not support analysis of system. Further research is required.

Energy Reduction + Conservation | HVAC

[variable refrigerant volume | system features]

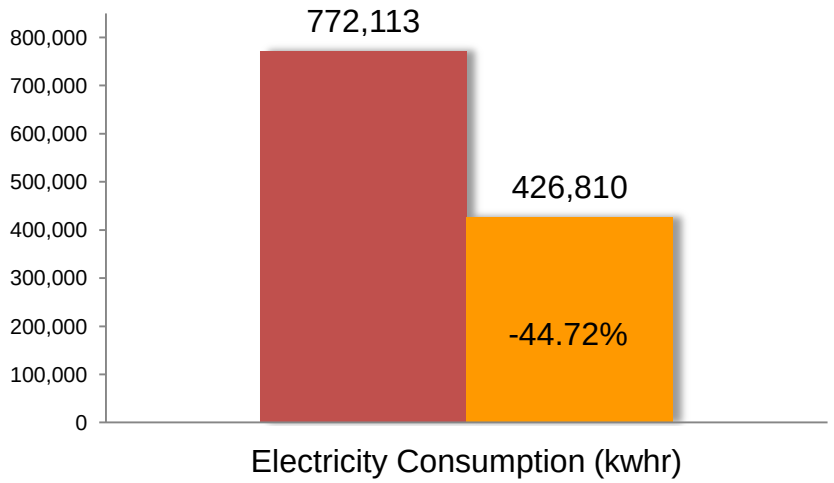
Variable Refrigeration Volume System With DOAS

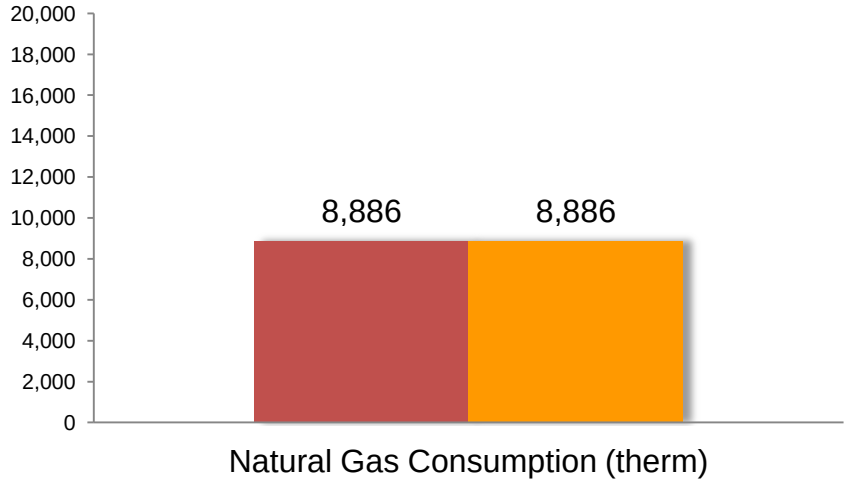
- Allows simultaneous high efficiency heating and cooling.
- Low temperature models operable to -13°F.
- Flexible zoning of indoor units.
- Couples with a true Dedicated Outdoor Air System to deliver ventilation air directly to spaces.

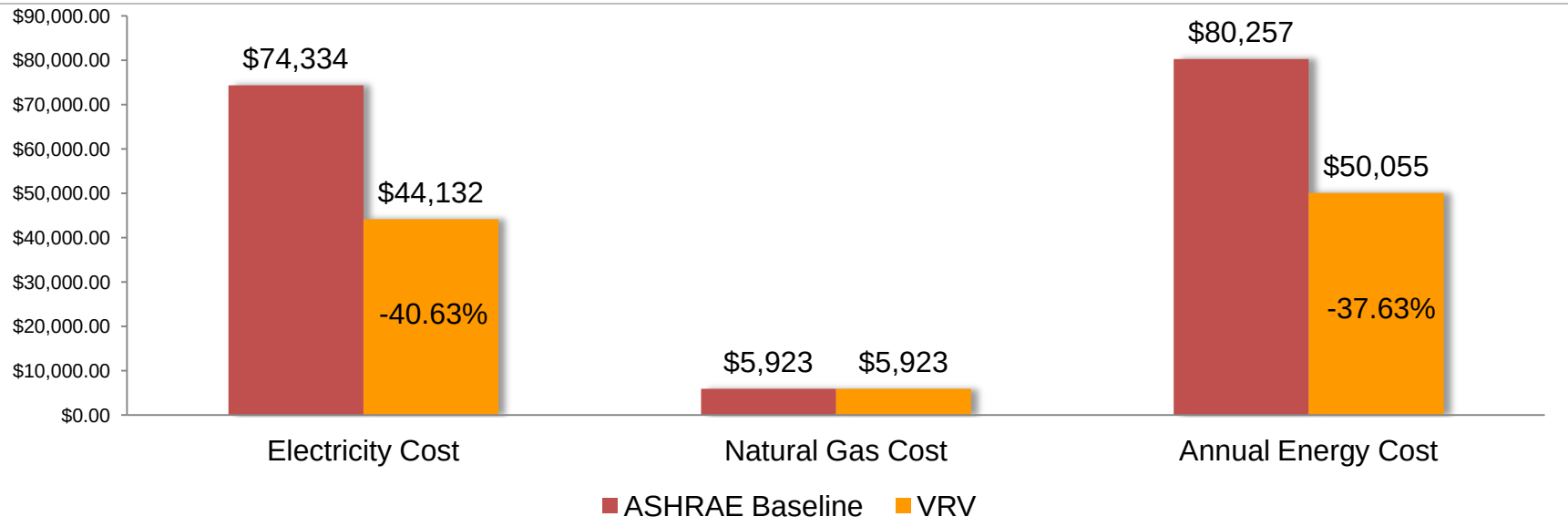


Energy Reduction + Conservation | HVAC

[variable refrigerant volume | energy modeling]







Energy Reduction + Conservation | HVAC

[variable refrigerant volume | life cycle cost]

Cost Component	ASHRAE DX/Electric Resistance Baseline System	Variable Refrigerant Volume System	Savings
Capital Cost	$ 929,307.00 *	$ 1,425,000.00 **	$ (495,693.00)
Energy Consumption Costs	$ 1,454,825.00	$ 898,454.00	$ 556,371.00
Energy Demand Costs	$ 1,396,468.00	$ 864,036.00	$ 532,432.00
Annual Recurring OM&R Costs	$ 411,400.00 **	$ 411,400.00**	$ -
Subtotal (Future Cost Items)	$ 3,262,693.00	$ 2,173,890.00	$ 1,088,803.00
40 Year PV Life Cycle Cost	**$ 4,192,000.00**	**$ 3,598,890.00**	**$ 593,110.00**

* Cost from LRL Cost Estimating

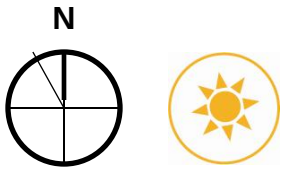
** Cost from historical data

Payback: Year 17 (YES)

LEED Percentage	EPAct Percentage
37.63% (Energy Cost Savings)	49.87% (Energy Savings)

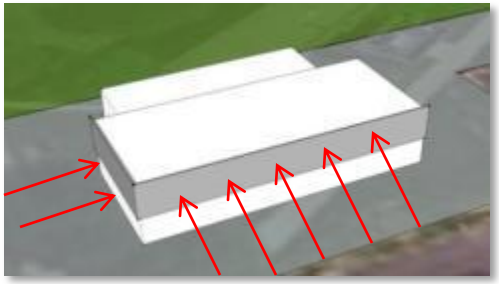
Energy Reduction + Conservation | HVAC

[renewable energy | solar thermal heated air collector]



Site rotated 21.5° of due South

COLLECTOR ORIENTATION:



Ideal

True South Wall (Max Solar Irradiance)

Favorable

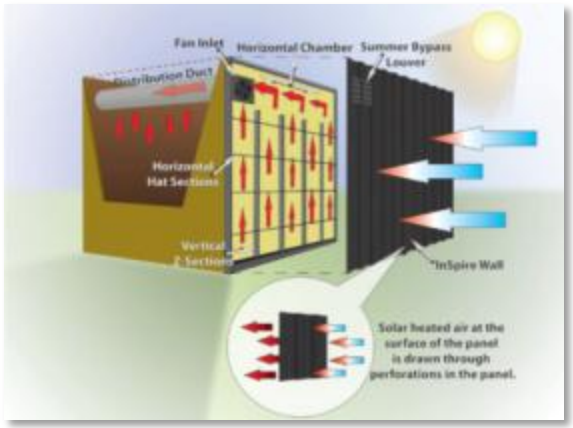
South West Wall

(90-100% of Max Solar Irradiance)

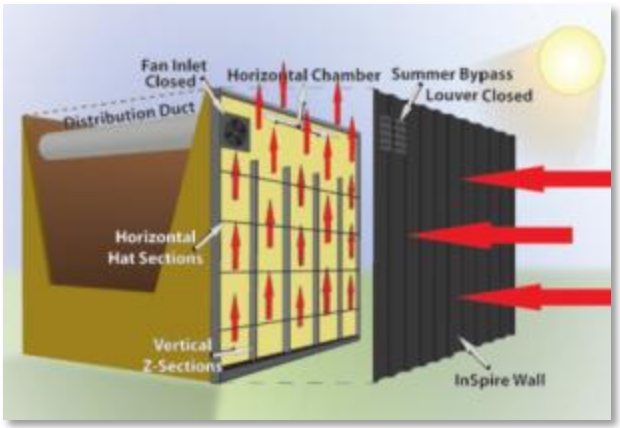
Non-Favorable

North Wall

CONNECTED TO DIRECT HEATING SYSTEM:



REDUCE HEATING LOAD IN SUMMER:



Proven renewable energy technology, in use for over 20 years.

1. Sun shines on solar collector.
2. Air is drawn through tiny perforations in collector.
3. Heated air is drawn to the top by fan/louver into building system

Construction / Installation:

1. Separate Panel system installed 4 - 8” from building wall.
2. Can be installed over or around existing wall openings.
3. Installed over non-combustible wall materials.
4. Easy installation – no special skills or tools needed.

Energy Reduction + Conservation | HVAC

[renewable energy | solar thermal heated air collector]

1. Panels are .032” Aluminum or pre-weathered .027” Zinc.
2. Wide variety of standard colors available (Preferably dark colored).
3. Over 240 perforations per sf.
4. Corrugated to increase structural rigidity.

Energy Reduction + Conservation | HVAC

[renewable energy | solar thermal heated air collector]

Building:

- OMS Vertical wall receives an average of 2.64 kWh/m^2/day

RETScreen Clean Energy Project Analysis Software:

- System Size: 1,255 ft^2
- System Cost: $21,335
- Annual Energy Savings: 39MBH/year

Annual Cost Savings:

$594 based on $6.25/1,000 cu ft natural gas

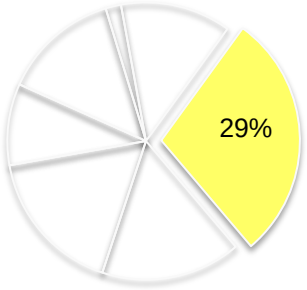
Payback:

Year 101 (NO – RECOMMENDED, GOOD DESIGN STRATEGY)

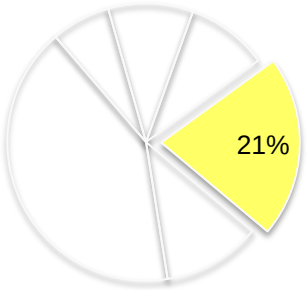
Energy Reduction + Conservation

[interior lighting | energy conserving measures]

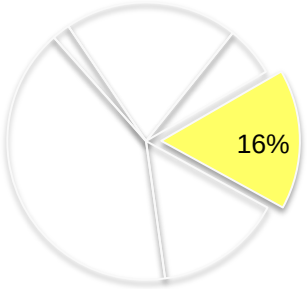
ARC
DX Cooling
Gas Heating
Baseline



ARC
DX Cooling
Electric Heating
Baseline



OMS
DX Cooling
Gas Heating
Baseline



BASE BID DESIGN (Planned)

- Motion sensor emergency lighting
- Occupancy sensors
- Vacancy sensors

FUTURE INVESTIGATION

- LED interior lighting
- Daylighting:
  - Solar tube
  - Clerestory
  - Sloped acoustic ceiling
  - Light shelves
  - Shading control

Energy Reduction + Conservation

[interior lighting | lighting controls | system features]

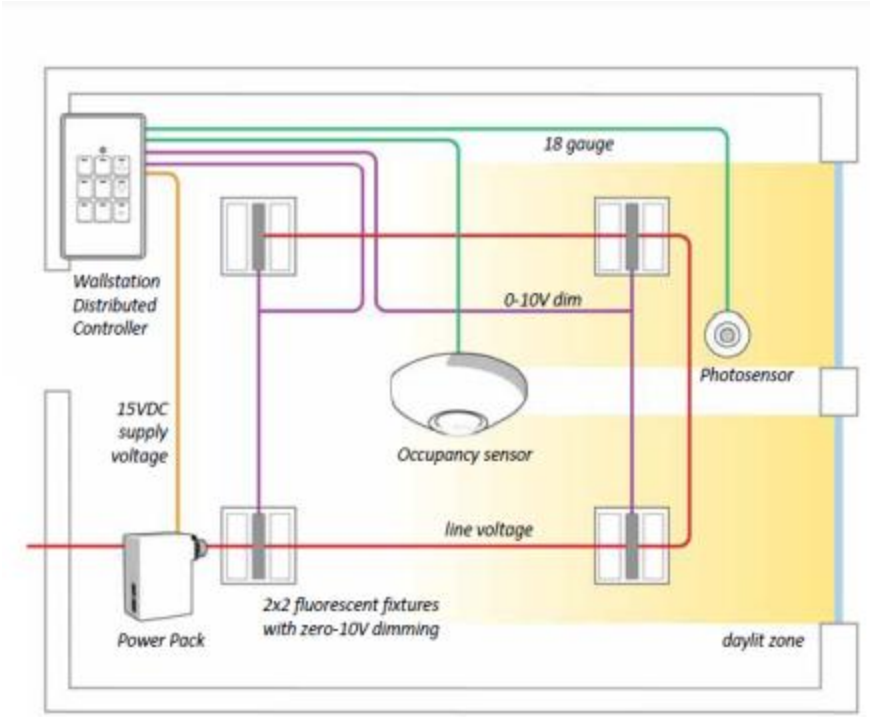
Integrated Lighting Control System

Occupancy/Vacancy Sensors – Automatically turns lights “off” when space is unoccupied.

Daylighting Controls – Actively dims artificial light sources in response to natural light levels.

Time clock – Can be programmed to turn lights “on” or “off”.

Based on case studies buildings designed with an integrated lighting control system utilizing combined strategies can approximately yield energy savings up to 40%.

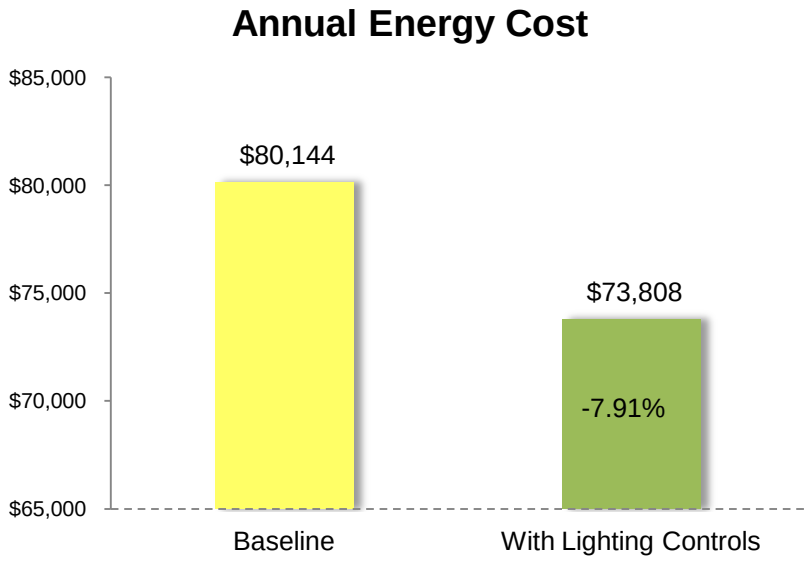


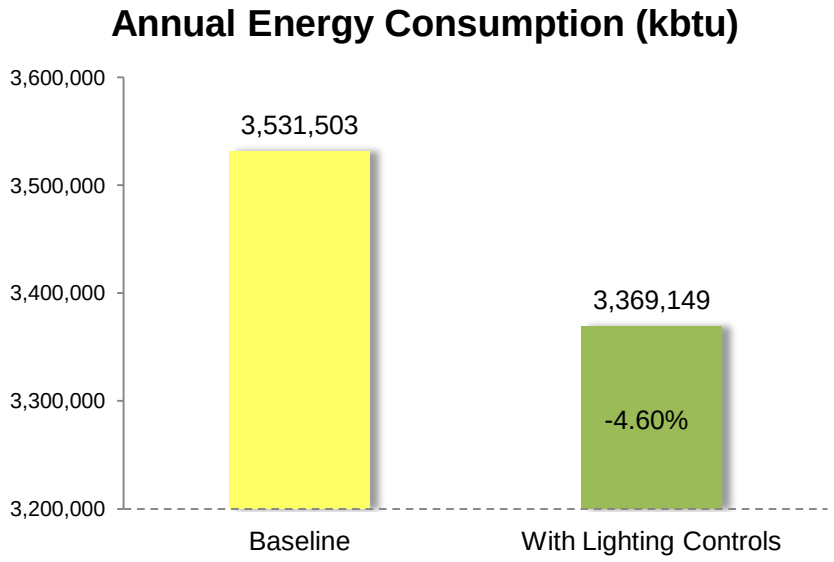
Additional energy saving strategies:

- Design facility to lower average ambient light levels (30fc) supplemented by task lights.
- Emergency light fixtures controlled by occupancy sensors.

Energy Reduction + Conservation

[ARC interior lighting | lighting controls | life cycle cost | gas heat baseline]





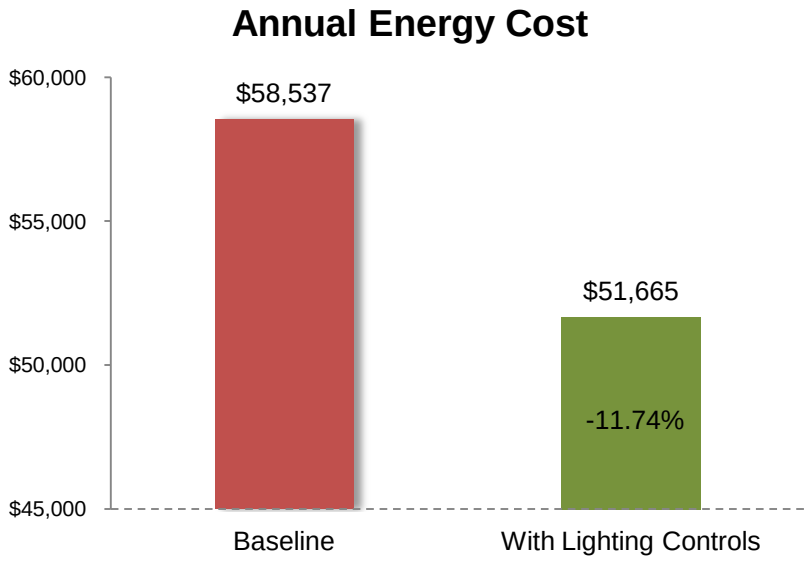
Cost Component	Baseline DX/Hydronic	Baseline DX/Hydronic With Lighting Controls	Savings
Capital Cost	$ 0 (Do Nothing)	$ 75,000	$ (75,000.00)
Energy Consumption Costs	$ 1,266,008.00	$ 1,174,990.00	$ 91,019.00
Energy Demand Costs	$ 824,828.00	$ 658,885.00	$ 165,943.00
Subtotal (Future Cost Items)	$ 2,090,836.00	$ 1,833,874.00	$ 256,962.00
40 Year PV Life Cycle Cost	**$ 2,090,836.00**	**$ 3,598,890.00**	**$ 181,962.00**

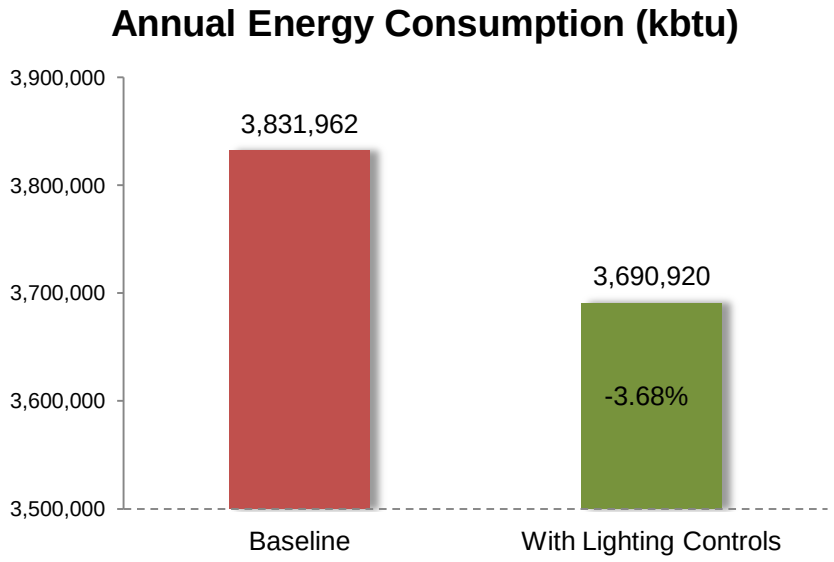
** Cost from historical data

Payback: Year 11 (YES)

Energy Reduction + Conservation

[ARC interior lighting | lighting controls | life cycle cost | electric heat baseline]





Cost Component	Baseline DX/Electric Resistance	Baseline DX/Electric Resistance With Lighting Controls	Savings
Capital Cost	$ 0 (Do Nothing)	$ 75,000	$ (75,000.00)
Energy Consumption Costs	$ 1,454,825.00	$ 1,382,172.00	$ 72,653.00
Energy Demand Costs	$ 1,396,468.00	$ 1,284,679.00	$ 111,789.00
Subtotal (Future Cost Items)	$ 2,851,293.00	$ 2,666,851.00	$ 184,442.00
40 Year PV Life Cycle Cost	**$ 2,851,293.00**	**$ 2,741,851.00**	**$ 109,442.00**

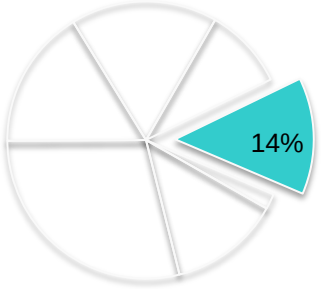
** Cost from historical data

Payback: Year 15 (YES)

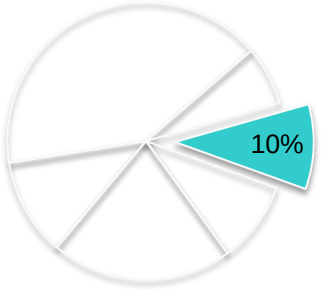
Energy Reduction + Conservation

[ventilation fans | energy conservation measures]

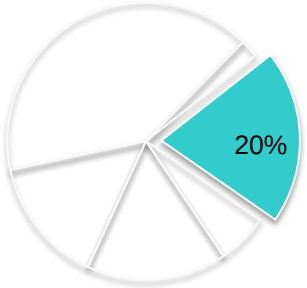
ARC
DX Cooling
Gas Heating
Baseline



ARC
DX Cooling
Electric Heating
Baseline



OMS
DX Cooling
Gas Heating
Baseline



BASE BID DESIGN (Planned)

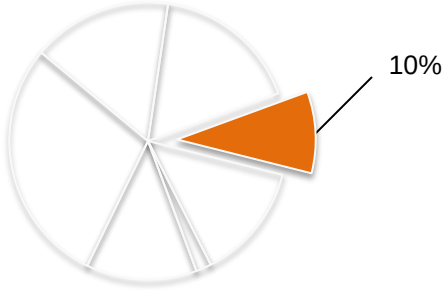
- Variable frequency drives
- HVAC zoning
- Occupancy sensors
- Vacancy sensors

FUTURE INVESTIGATION

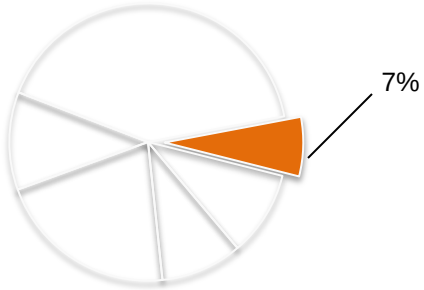
- Passive/natural ventilation

Energy Reduction + Conservation

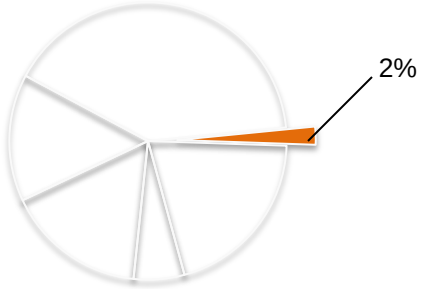
[domestic water heating | energy conservation measures]



ARC
DX Cooling
Gas Heating
Baseline



ARC
DX Cooling
Electric Heating
Baseline



OMS
DX Cooling
Gas Heating
Baseline

BASE BID DESIGN (Planned)

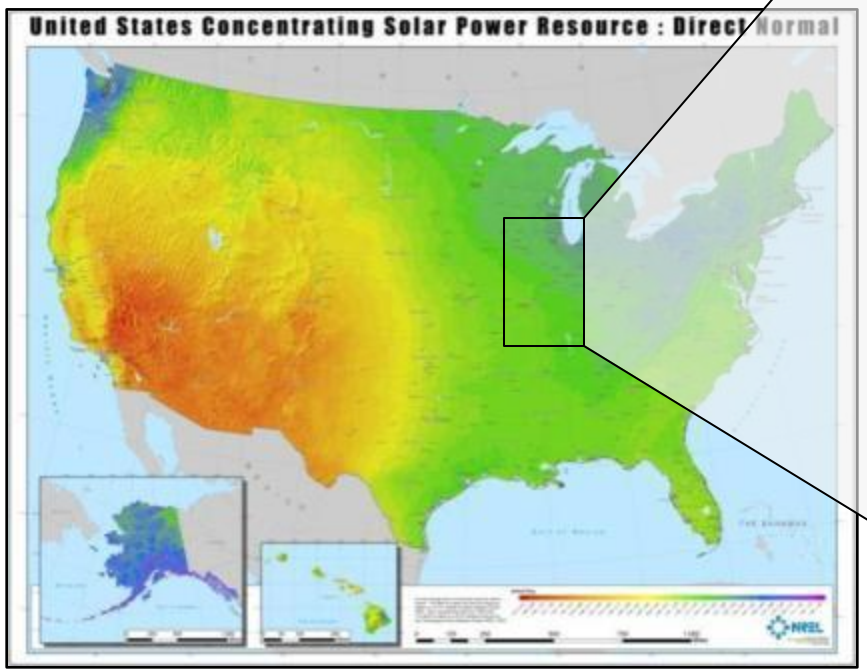
- Solar water heating
- Low flow fixtures

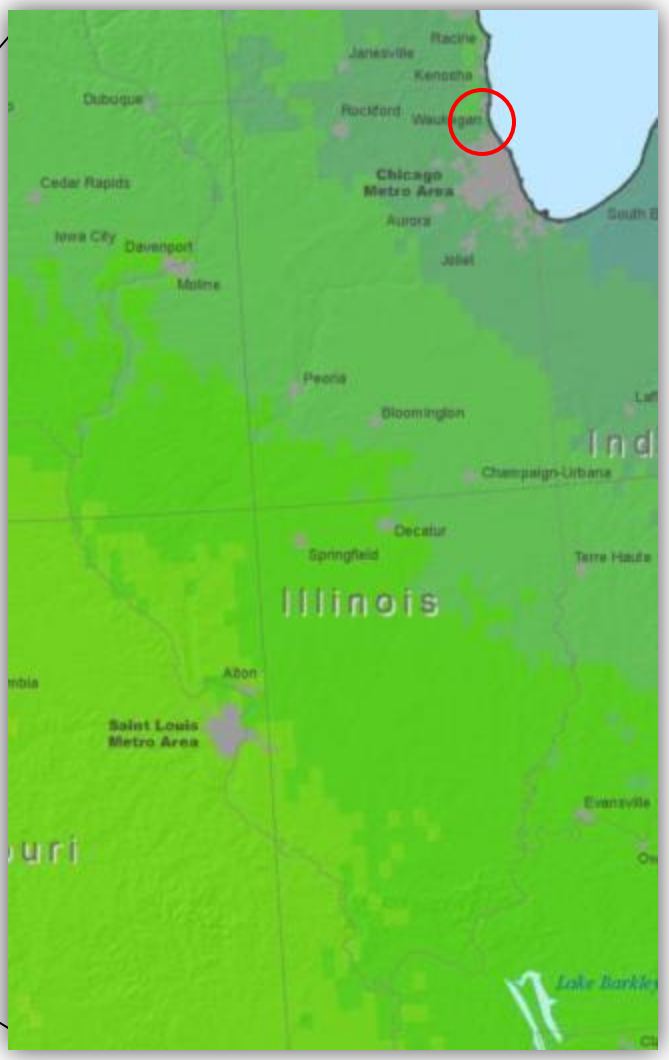
FUTURE INVESTIGATION

- Instantaneous water heating

Energy Reduction + Conservation

[renewable energy | regional context | solar]





Energy Reduction + Conservation

[renewable energy | solar hot water heating]

REQUIRED PER:

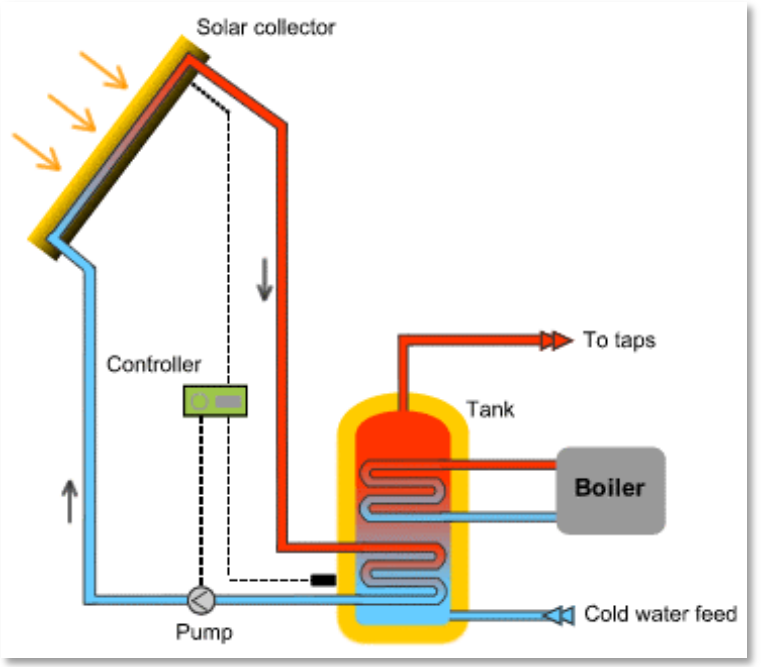
Energy Independence and Security Act of 2007

- Requires 30% of the hot water demand to be met by solar hot water system.

Sustainable Design and Development Policy Update

(Environmental and Energy Performance)

- Provide Solar Hot Water Heating for 30% of hot water demand if
  - Building average daily hot water requirement is 50 gallons or more.
  - Building located in an area that receives an average of 4kWh/m^2/day average solar radiation annually.



Energy Reduction + Conservation

[renewable energy | solar hot water heating]

Project Site:

- Building uses 61 gallons of hot water per day
- Site receives an average solar radiation of 3.92 kWh/m^2/day

NREL Solar Hot Water System Calculator:

- System Size: 63.7 ft^2
- System Cost: $8,386.43
- Annual Energy Savings: 4,667.01 kWh/year

Annual Cost Savings:

[Gas]
$96.91 based on $6.25/1,000 cu. ft. natural gas

[Electric] – NOT RECOMMENDED
$345.26 based on $0.0860/kWh

Payback:

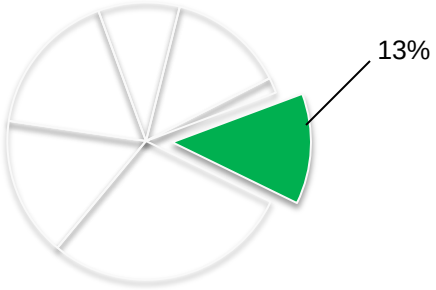
[Gas]
Year 87 (NO)

[Electric]
Year 24 (YES)

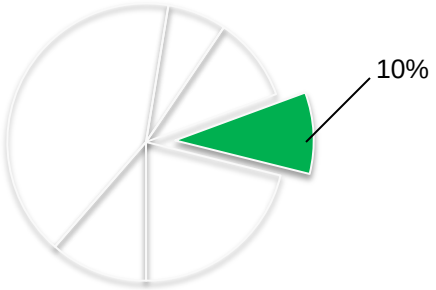
Energy Reduction + Conservation

[misc. equipment | energy conserving measures]

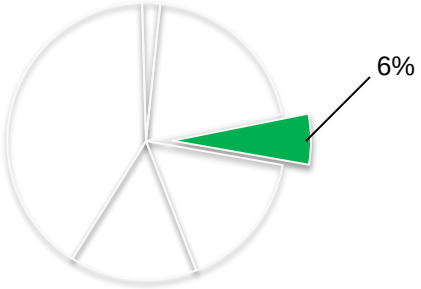
ARC
DX Cooling
Gas Heating
Baseline



ARC
DX Cooling
Electric Heating
Baseline



OMS
DX Cooling
Gas Heating
Baseline



BASE BID DESIGN (Planned)

- Plug load control
- EnergyStar equipment
- LED task lighting
- Centralized printing

INVESTIGATIVE STUDIES (Researched)

- Solar power/photovoltaic
- Wind power

FUTURE INVESTIGATION

- Security system process load control

Energy Reduction + Conservation

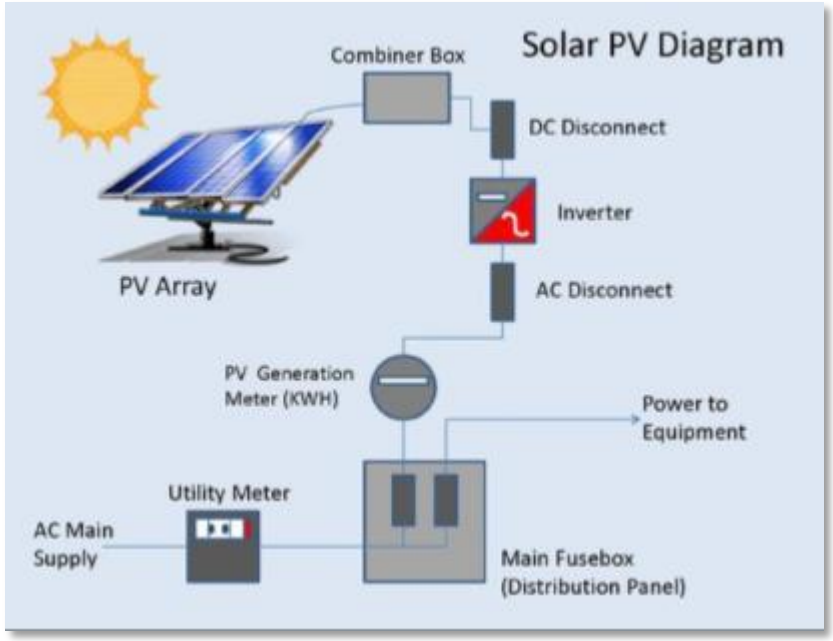
[renewable energy | photovoltaic | system features]

Solar Photovoltaic System:

- Provides on-site renewable energy – necessary to meet “Net-Zero” goal
- Site selection – PV array should be located to allow for expansion
- Incentives and rebates can help offset high initial cost

Component Life:

PV module:	30 years
Inverter:	15 years



Energy Reduction + Conservation

[renewable energy | photovoltaic | alternative site lighting solutions]

Inovus Solar® | http://www.inovussolar.com/home.aspx

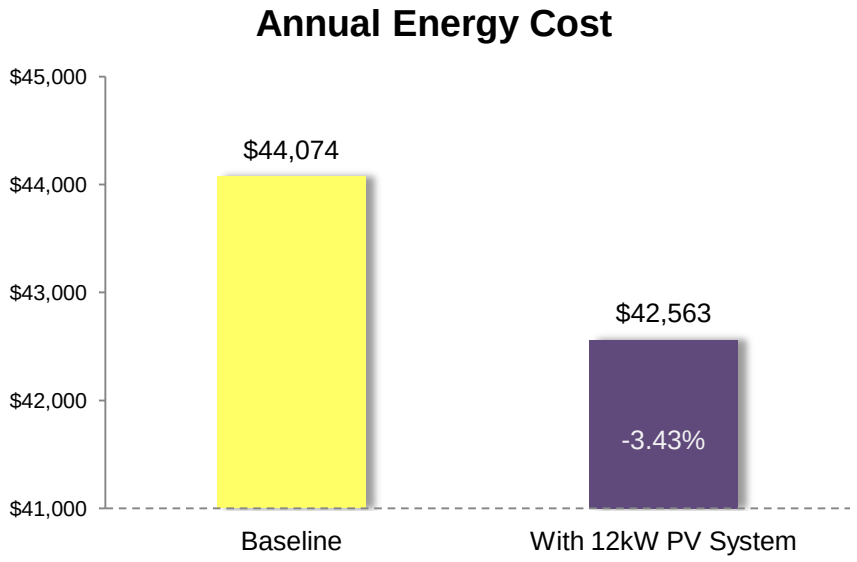
"Superior aesthetics, cost savings and reliability."

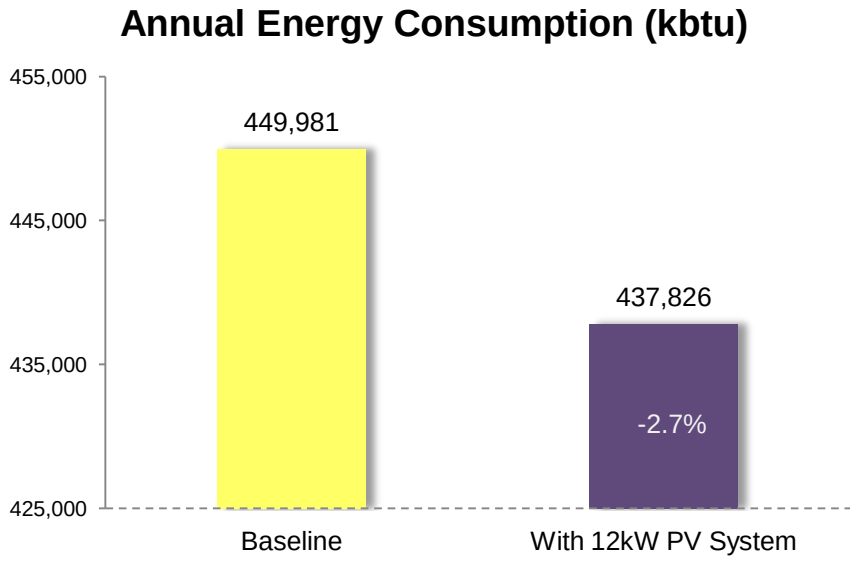
http://www.youtube.com/watch?v=1QLTVpG8cpY&feature=related

1. Flexible, thin-film solar wrap eliminates the poor aesthetics of unsightly flat panels and is a more durable, lower maintenance alternative. No Array panel needed (top of pole or remote).
2. Intelligent energy management and wireless lighting controls significantly lower operating costs over the long-term.
3. Inovus Solar® products integrate tested and proven components to create a more reliable system.
4. Off-Grid and On-Grid products depending on your specific application 15' and 25' tall versions of both the Off-Grid and On-Grid products are available.
   - Used for Military Application (Off-Grid): http://www.inovussolar.com/applications/military.aspx
5. Economic and environmental impacts of the category are improved, providing superior value for our customers and shifting the paradigm of the industry.
   - http://www.inovussolar.com/value/economicaltobuy.aspx
   - Cost comparison to be provided by PDT: Traditional PV site light systems vs. Inovus Solar® System.

Energy Reduction + Conservation

[renewable energy | photovoltaic | life cycle cost | gas heat baseline]



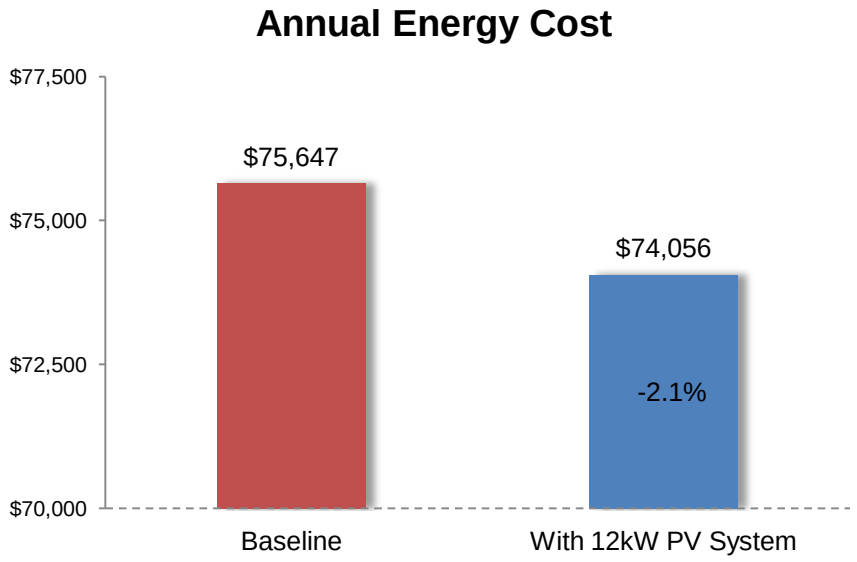


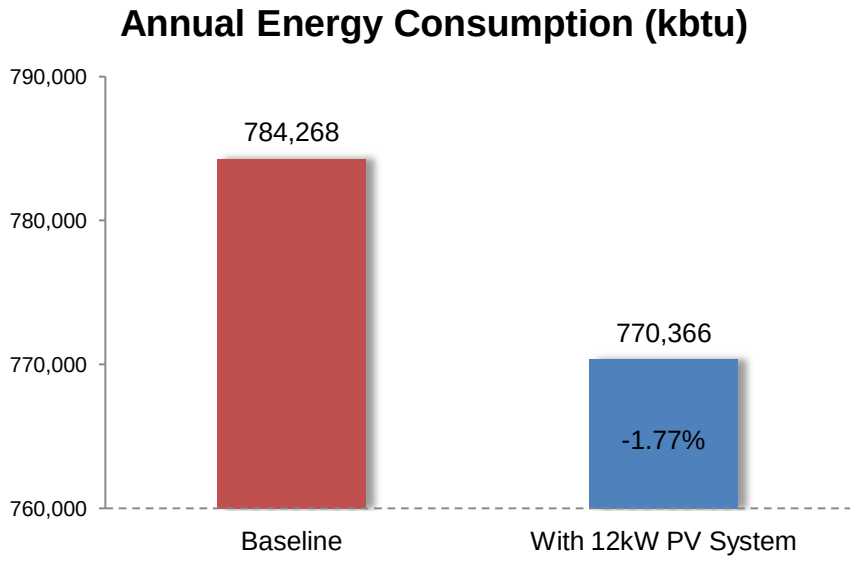
Cost Component	Baseline DX/Hydronic	Baseline DX/Hydronic With 12kW PV System	Savings
Capital Cost	$ 0 (Do Nothing)	$ 97,064	$ (97,064.00)
Energy Consumption Costs	$ 671,156.00	$ 653,026.00	$ 18,129.00
Energy Demand Costs	$ 763,533.00	$ 732,479.00	$ 31,054.00
Routine Recurring and Non-Recurring OM&R Costs	$ 0	$ (13,864.00)	$ (13,864.00)
Subtotal (Future Cost Items)	$ 1,434,689.00	$ 1,399,369.00	$ 35,320.00
40 Year PV Life Cycle Cost	**$ 1,434,689.00**	**$ 1,496,433.00**	**$ (61,744.00)**

Payback: NO

Energy Reduction + Conservation

[renewable energy | photovoltaic | life cycle cost | electric heat baseline]



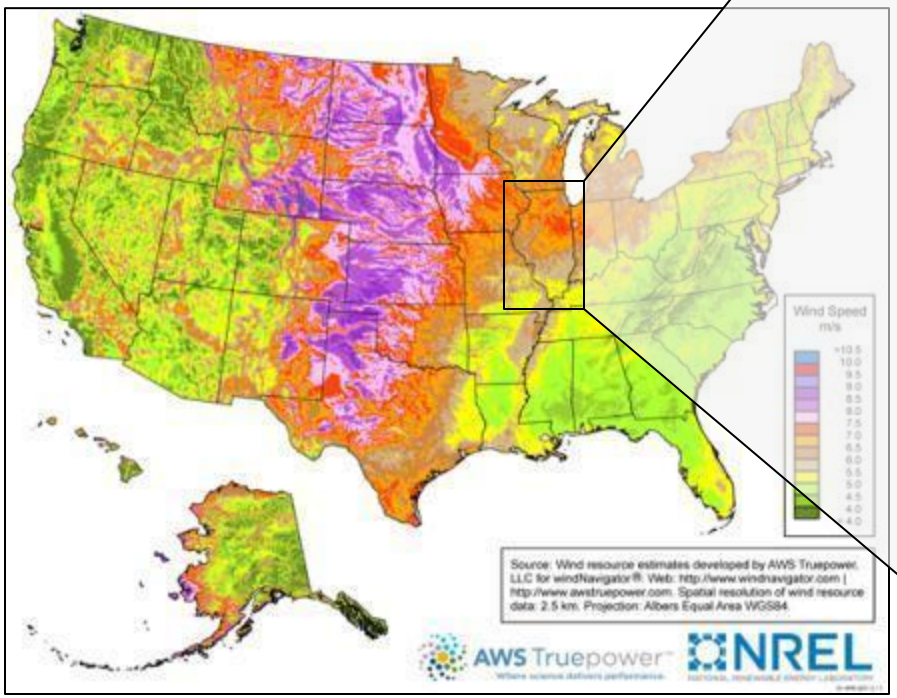


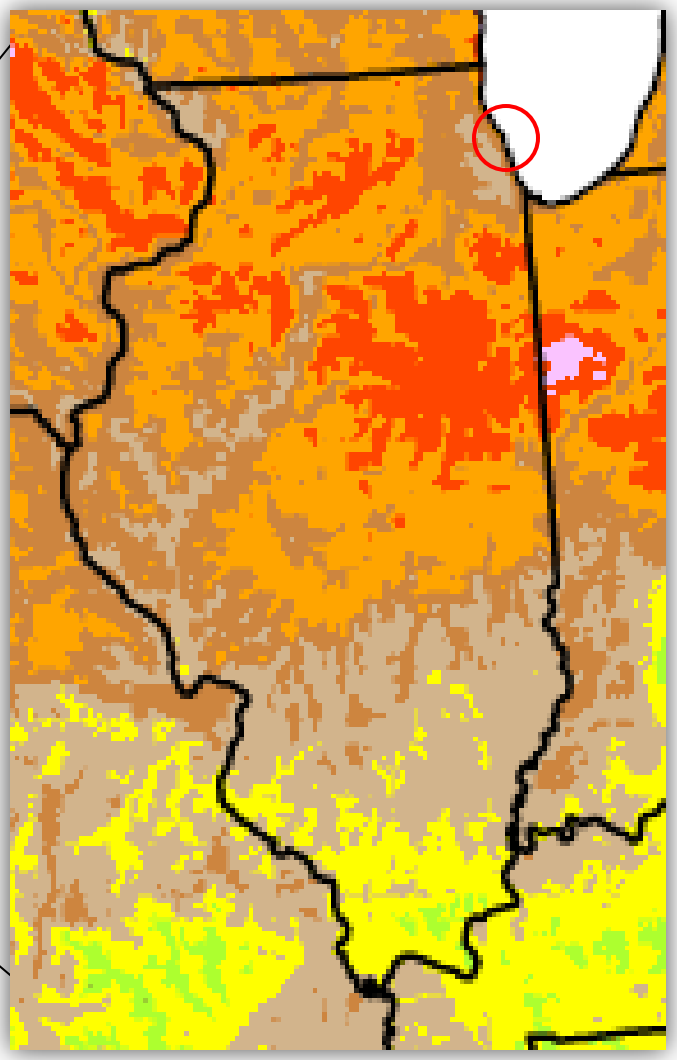
Cost Component	Baseline DX/Electric Resistance	Baseline DX/Electric Res. With 12kW PV System	Savings
Capital Cost	$ 0 (Do Nothing)	$ 97,064	$ (97,064.00)
Energy Consumption Costs	$ 1,169,751.00	$ 1,149,016.00	$ 20,735.00
Energy Demand Costs	$ 1,292,694.00	$ 1,261,640.00	$ 31,054.00
Routine Recurring and Non-Recurring OM&R Costs	$ 0	$ (13,864.00)	$ (13,864.00)
Subtotal (Future Cost Items)	$ 2,462,445.00	$ 2,424,520.00	$ 37,926.00
40 Year PV Life Cycle Cost	**$ 2,462,445.00**	**$ 2,521,584.00**	**$ (59,138.00)**

Payback: NO

Energy Reduction + Conservation

[renewable energy | regional context | wind]





Energy Reduction + Conservation

[renewable energy | wind power turbine | life cycle cost]

Project Site:

- Average wind velocity of 10.7 mph.
- 6-10 mph is the min. for generation of power (Cut-in Speed).

RETScreen Clean Energy Project Analysis Software:

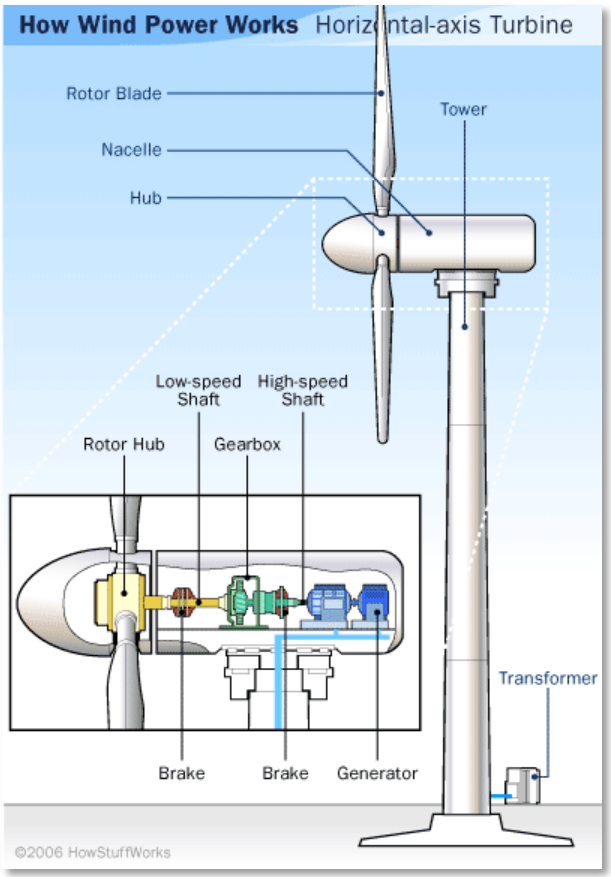
- System Size: 10 kW (Parking lot lighting)
- System Cost: $75,000
- Annual Energy Savings: 12MWH

Annual Cost Savings:

$594 based on $0.0860/kWh

Payback:

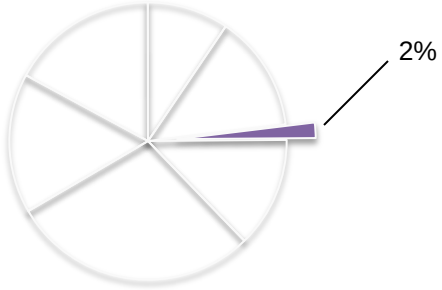
Year 95 (NO)



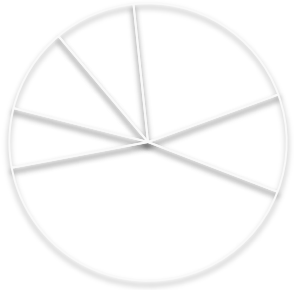
Energy Reduction + Conservation

[pumps | energy conserving measures]

ARC
DX Cooling
Gas Heating
Baseline



ARC
DX Cooling
Electric Heating
Baseline



OMS
DX Cooling
Gas Heating
Baseline

BASE BID DESIGN (Planned)

- Variable frequency drives
- HVAC zoning

Energy Reduction + Conservation

[other energy conserving measures]

BASE BID DESIGN (Planned)

- Solar site lighting
- Energy dashboard/signage (user education)

[Lunch]

Summarize Decisions | Discussion

[HVAC systems | life cycle cost]

Cost Component	ASHRAE DX/Hydronic Baseline System	Variable Air Volume System With ERV	Four Pipe Fan Coil System With DOAS	ASHRAE DX/Electric Resistance Baseline System	Ground Source Heat Pump System With ERV	Water Source Heat Pump System With ERV	Variable Refrigerant Volume System With DOAS
Capital Cost	$ 1,151,272.00 *	$ 1,412,471.00 *	$ 1,282,014.00*	$ 929,307.00 *	$ 1,547,362.00 **	$ 1,357,335.00 **	$ 1,425,000.00 **
Energy Consumption Costs	$ 1,266,008.00	$ 1,188,574.00	$ 1,036,236.00	$ 1,454,825.00	$ 1,528,194.00	$ 1,441,127.00	$ 898,454.00
Energy Demand Costs	$ 824,828.00	$ 773,592.00	$ 693,592.00	$ 1,396,468.00	$ 982,120.00	$ 931,377.00	$ 864,036.00
Annual Recurring OM&R Costs	$ 598,412.00 **	$ 822,799.00 **	$ 897,618.00 **	$ 411,400.00 **	$ 448,809.00 **	$ 897,618.00 **	$ 411,400.00**
Subtotal (Future Cost Items)	$ 2,689,248.00	$ 2,784,966.00	$ 2,627,446.00	$ 3,262,693.00	$ 2,959,123.00	$ 3,270,122.00	$ 2,173,890.00
40 Year PV Life Cycle Cost	$ 3,840,520.00	$ 4,197,437.00	$ 3,909,460.00	$ 4,192,000.00	$ 4,506,485.00	$ 4,627,457.00	$ 3,598,890.00

* Cost from LRL Cost Estimating

** Cost from historical data

PDT Recommended HVAC System – Payback: Year 17

Summarize Decisions | Discussion

[HVAC systems | initiative savings]

HVAC System	Variable Air Volume With ERV	Four Pipe Fan Coil With DOAS	Ground Source Heat Pump With ERV	Water Source Heat Pump With ERV	Variable Refrigerant Volume With DOAS
LEED Percentage	6.03%	17.06%	11.35%	16.23%	37.63%
LEED EAc1 Points	0	3	0	3	15
EPAct Percentage	17.27%	28.81%	-6.58%	-9.68%	49.87%

PDT Recommended HVAC System – Payback: Year 17

[Summarize Decisions]

Remarks:

- ARIMD Project Officer
- USACE – Louisville District PM

[Charrette Wrap-up]

Remarks:

- ARIMD Project Officer
- USACE – Louisville District PM